BULLETIN OF THE IMPERIAL INSTITUTE

A QUARTERLY RECORD OF PROGRESS IN TROPICAL AGRICULTURE AND INDUSTRIES AND THE COMMERCIAL UTILISATION OF THE NATURAL RESOURCES OF THE COLONIES AND INDIA

EDITED BY THE DIRECTOR AND PREPARED BY THE SCIENTIFIC AND TECHNICAL STAFF OF THE IMPERIAL INSTITUTE AND BY OTHER CONTRIBUTORS

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VOL. XV. 1917

CONTENTS

CONTENTS

SPECIAL ARTICLES

GENERAL ARTICLES

NOTES

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

THE IMPERIAL INSTITUTE

OF THE

UNITED KINGDOM, THE COLONIES, AND INDIA

THE Imperial Institute was erected at South Kensington as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire: (i) by arranging comprehensive exhibitions of natural products, especially of the Dominions, Colonies and India; and (ii) by providing for their investigation, and for the collection and dissemination of scientific, technical and commercial information relating to raw materials.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales (afterwards King Edward VII.) was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned, subject to rights of usage, for occupation by the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee including representatives of the Dominions, Colonies and India, as well as of the

Colonial and India Offices, the Board of Agriculture and the Board of Trade.

In April 1916 the Imperial Institute (Management) Act was passed transferring the property and management of the Imperial Institute to the Secretary of State for the Colonies. The Act provides for the appointment of an Executive Council consisting of twenty-five members, nominated by the Board of Trade, the Secretary of State for India (two each), the President of the Board of Agriculture and Fisheries, the Government of India, the Governments of the several Dominions (one each), and the Secretary of State for the Colonies (fourteen). A list of the present members of the Council is given on pp. x, xi and also of the various Committees which have been appointed (pp. xi–xv).

The staff of the Imperial Institute includes officers with special qualifications in the sciences of chemistry, botany, geology and mineralogy, and in certain branches of technology, in their relation to commerce and to the industrial utilisation of raw materials.

The following are the principal departments of the Institute:

Public Exhibition Galleries.—The collections of raw materials, etc., illustrative of the industrial and commercial resources of the Dominions, Colonies and India, are arranged, together with other exhibits, on a geographical system in the public galleries of the Imperial Institute. The galleries are open free to the public, daily (except on Sundays, Good Friday and Christmas Day), from 10 a.m. to 5 p.m. in summer, and from 10 a.m. to 4 p.m. in winter.

The following British Dominions, Colonies and Dependencies are represented by Collections, which are in charge of Technical Superintendents:

Canada, Newfoundland; Jamaica, Turks and Caicos

Islands, British Honduras, British Guiana, Bahamas, Trinidad and Tobago, Barbados, Windward Islands, Leeward Islands, Bermuda; Falkland Islands; New South Wales, Victoria, Queensland, Tasmania, South Australia, Western Australia, Papua, New Zealand; Fiji, Western Pacific Islands; Union of South Africa, Rhodesia, Nyasaland, St. Helena; Gambia, Sierra Leone, Gold Coast, Nigeria; East Africa Protectorate, Zanzibar and Pemba; Uganda; Somaliland; Sudan; Malta; Cyprus; Ceylon; Hong Kong; Mauritius; Seychelles; Straits Settlements, the Federated Malay States; and the Indian Empire.

An Egyptian collection is in course of formation.

A reference collection of standard raw materials of commerce is shown in the Upper East Gallery.

Arrangements are made to conduct parties from schools and educational institutions through the Collections and to explain the exhibits. Short lectures on the countries of the Empire and their resources are given periodically in connection with the Collections.

A Central Stand for the distribution of publications and an Enquiry Office have been opened in the main gallery to provide for the supply of general information and the distribution of literature. Handbooks, pamphlets, circulars, etc., containing information relating to the commerce, agriculture, mining and other industries of the Dominions and Colonies, and also in regard to emigration, are available for free distribution or for sale. The publications of the Emigrants' Information Office may also be obtained. Lists of the publications available for distribution or sale are provided, and the principal Colonial and Indian newspapers may be seen on application.

In 1916 the public galleries were visited by 162,854 persons, and 11,991 publications were distributed.

Scientific and Technical Research Department.—The technical laboratories and workrooms of this Department were

established in order to provide for the investigation of new or little-known raw materials from the Dominions, Colonies and India, and of known products from new sources, with a view to their utilisation in commerce.

The work of this Department is chiefly initiated by the Home, Dominion and Colonial Governments and the Government of India. Arrangements have been also made by the Foreign Office whereby Consular representatives abroad may transmit to the Department, for investigation, such raw materials of the countries to which they are appointed as are likely to be of interest to British manufacturers and merchants.

Special analyses and investigations are also undertaken for firms or private persons in any part of the Empire on payment of appropriate charges. Application for such investigations should be made, in writing, to the Director.

Materials investigated in the laboratories of the Department are in promising cases submitted to further technical trials by manufacturers and other experts, and finally are commercially valued.

A Reference Sample Room is maintained in this Department, in which are arranged samples of the principal raw materials which have been investigated and valued commercially during recent years, and as to which full information is available.

The Department works in co-operation with the Agricultural, Mines and other Technical Departments in the Dominions, Colonies and India, whose operations it supplements by undertaking investigations and enquiries of a special scientific or technical character connected with agricultural or mineral development, as well as enquiries relating to the composition and commercial valuation of products (animal, vegetable or mineral) which can be more efficiently conducted at home in consultation with

manufacturers and merchants, with a view to the local utilisation of these products or to their export.

A large number of reports on these subjects have been made to the Governments of the Dominions, the Colonies and India, a first instalment of which was printed in a volume of *Technical Reports and Scientific Papers*, published in 1903. A series of Selected Reports is now being issued in the Miscellaneous Series of Colonial Reports which are presented to Parliament (p. viii).

Mineral Surveys are conducted in countries of which the mineral resources are little known. All minerals found that are likely to be of commercial importance are forwarded to the Imperial Institute, where they are examined and their composition and commercial value ascertained. Reports on the results of mineral exploration in Ceylon, Northern Nigeria, Southern Nigeria, and Nyasaland have been printed in the Miscellaneous Series of Colonial Reports and presented to Parliament.

Technical Information Bureau.—This Bureau, which is a branch of the Scientific and Technical Research Department, has been formed to deal with the large and increasing number of enquiries received by the Imperial Institute from manufacturers, merchants and others, throughout the Empire. The Bureau has devoted special attention to questions arising out of the war, particularly those relating to the opportunities presented for the development, within the Empire, of industries the raw materials of which were formerly monopolised by Germany. It has supplied technical information to enquirers, and has issued circulars and pamphlets dealing with various problems in connection with the supply and disposal of raw materials.

Indian Trade Enquiry.—The Secretary of State for India has requested the Indian Committee of the Institute to

enquire into and report on the possibilities of extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire. A number of Special Committees have been appointed to deal with the more important groups of Indian materials, to consider the results of investigations and enquiries already conducted at the Imperial Institute, and to obtain the views of leading merchants, manufacturers and other users of the raw materials of India. A list of the members of these Special Committees is given on pp. xiii and xiv.

Tropical African Services Course.—Courses of instruction in certain specified subjects are given at the Imperial Institute to candidates selected by the Colonial Office for administrative appointments in East and West Africa. Instruction in these Courses in the subject of Tropical Economic Products is given by a member of the Staff of the Imperial Institute. The Courses have been temporarily discontinued during the war.

Library, Reading-Rooms, and Map-Room.—The library and reading-rooms of the Imperial Institute contain a large collection of works of reference, and are regularly supplied with the more important official publications, and with many of the principal newspapers and periodicals of the United Kingdom, the Dominions, the Colonies, India and Foreign Countries. Special attention is given to publications relating to tropical agriculture and forestry, mineral resources, and the production and utilisation of raw materials.

The map-room, which adjoins the reading-rooms, is provided with a large collection of recent maps of the Dominions, the Colonies and India, which can be seen on application to the Librarian.

Colonial Conference Rooms.—These rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Dominions and Colonies and for meetings and receptions.

The Cowasjee Jehangier Hall.—The Bhownaggree corridor and rooms in connection with the Cowasjee Jehangier Hall are in the occupation of the Indian Section of the Imperial Institute, whilst the Hall is available for lectures, meetings, etc.

Publications

Bulletin of the Imperial Institute.—The BULLETIN is published quarterly by Mr. John Murray, 50A, Albemarle Street, London, price *2s. 6d.* (annual subscription, 11s., including postage), and may be purchased through any bookseller. It contains records of the principal investigations carried out at the Imperial Institute, and special articles chiefly relating to the industrial utilisation of raw materials and progress in tropical agriculture.

Handbooks to the Commercial Resources of the Tropics.—The Secretary of State for the Colonies has authorised the preparation of a series of handbooks dealing with the Commercial Resources of the Tropics, with special reference to West Africa. The handbooks are edited by the Director of the Imperial Institute and published by Mr. John Murray. The first three volumes are: *The Agricultural and Forest Products of British West Africa*, by Gerald C. Dudgeon, Consulting Agriculturist, Ministry of Agriculture, Egypt, and lately Inspector of Agriculture for British West Africa, price 5*s.* net; *Cocoa: Its Cultivation and Preparation*, by W. H. Johnson, F.L.S., Director of Agriculture in Southern Nigeria, price 5*s.* net; and *Rubber: Its Sources, Cultivation and Preparation*, by Harold Brown, Technical Superintendent, Scientific and Technical Department, Im-

perial Institute, price 6s. net. A fourth volume, *Cotton and other Vegetable Fibres: their Production and Utilisation*, by Ernest Goulding, D.Sc., F.I.C., Scientific and Technical Department, Imperial Institute, is in the press.

Monographs on Industries.—The Imperial Institute has devoted special attention to the question of securing the utilisation in the United Kingdom of the large quantities of materials produced within the Empire which before the war were exported chiefly to foreign countries. It is intended to deal with this subject in a series of Monographs. In order to call attention to the subject of oil seeds, a monograph, entitled "Oil Seeds and Feeding Cakes," has been issued. This book, which is published by Mr. John Murray, price 2s. 6d. net, deals with the production and utilisation of copra, palm kernels, ground nuts, sesame seed and mowra seed, and the oils and feeding cakes obtained from them.

Selected Reports from the Scientific and Technical Department.—These reports are issued in the Miscellaneous Series of Colonial Reports, which are presented to Parliament. They contain a summary of the results of technical and commercial investigation of raw materials conducted in the Scientific and Technical Research Department of the Imperial Institute since 1903. Five of these Selected Reports have been published: Part I. "Fibres"; Part II. "Gums and Resins"; Part III. "Foodstuffs"; Part IV. "Rubber and Gutta Percha"; Part V. "Oil-seeds, Oils, Fats and Waxes."

Organisations with Headquarters at the Institute

International Association for Tropical Agriculture, British Section.—The object of this Association, the Central Bureau of which is in Paris, is to promote the scientific and practical study of all questions connected with the

agriculture of tropical countries, including the development and utilisation of natural resources, and to hold periodical International Congresses. The British Section has its headquarters at the Imperial Institute. Members of the British Section are permitted to use the library and reading-rooms of the Imperial Institute.

British Women's Emigration Association.—The British Women's Emigration Association has offices on the mezzanine floor, which are open daily from 10 a.m. to 4 p.m. Advice and information respecting emigration and prospects for women in the Dominions may be obtained there free of charge. This Association works in co-operation with the Emigrants' Information Office in Westminster.

Colonial Nursing Association.—An office on the mezzanine floor has been allotted to this Association, the principal object of which is the selection of trained hospital and private nurses for service in the Crown Colonies and Dependencies.

Tropical Diseases Bureau.—Temporary office accommodation on the mezzanine floor has been provided for this Bureau, the main purpose of which is to collect information regarding tropical diseases and to distribute it as widely as possible among those who are engaged in combating such diseases.

Universities Bureau of the British Empire.—An office on the mezzanine floor has been allotted to this Bureau, the object of which is the collection and dissemination of information relating to the Universities of the British Empire.

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REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

SOME NEW PAPER-MAKING MATERIALS

In the following pages an account is given of the results of examination of *Ecdeiocolea monostachya* "leaves" from Western Australia, *Neoboutonia macrocalyx* timber from the East Africa Protectorate, and bark of *Brachystegia Randii* from Rhodesia, which have been investigated at the Imperial Institute recently as sources of pulp for paper-making.

Ecdeiocolea monostachya "Leaves" from Western Australia

E. monostachya, F. Muell., is a rush-like plant belonging to the natural order Restiaceæ, and is found only in Western Australia. The stems or so-called "leaves" are erect, rigid, rather slender, and vary in height from 2 to 5 ft.; they bear a number of sheathing, brown scales at the base, the upper part being bare, except for a single sheath just below the terminal flowering head.

Early in 1916 a sample of the "leaves" was sent to the Imperial Institute from Western Australia, for the purpose of ascertaining whether the material would be of commercial value as a source of fibre for paper-making or other purposes.

The sample consisted of narrow green "leaves" varying from 3 to 5 ft. in length, most of them being about 4 ft. long. The "leaves" were round in cross-section, and measured

about $\frac{1}{8}$ in. in diameter at the base, tapering to less than $\frac{1}{16}$ in. at the apex. The surface of the "leaves" was somewhat waxy.

The "leaves" were examined at the Imperial Institute as a paper-making material with the following results:

Moisture, in the "leaves" as received	*per cent.*	10·1
Ash, expressed on the "leaves" dried at 105° C.	"	3·0 [1]
Cellulose, expressed on the "leaves" dried at 105° C.	"	49·5
Length of ultimate fibres		2·0 to 5·4 mm. (0·08 to 0·22 in.)

[1] *Containing* 40·1 *per cent. of silica* (SiO_2).

The "leaves" were treated by a method similar to that employed on a large scale for the preparation of paper-pulp from esparto grass, *i.e.* they were digested under pressure with 16 parts by weight of caustic soda, of 4 per cent. strength, for 4 hours at 140° C. The following result was obtained, in comparison with those given by two commercial specimens of esparto grass treated in the same way:

	Yield of pulp from air-dry material. *Per cent.*
E. monostachya "leaves"	44
Spanish esparto grass	52
Algerian esparto grass	42

From these results it is evident that *E. monostachya* "leaves" yield about the same amount of pulp as Algerian (Oran) esparto grass. The pulp is, however, inferior in appearance to that yielded by esparto grass, and the unbleached pulp yields a darker-coloured paper, whilst the pulp is somewhat difficult to bleach. Further, the paper prepared from *E. monostachya* "leaves" shows small bright yellow specks, due to the presence of a waxy or resinous substance, of which the "leaves" yield about 2·7 per cent. on extraction with alcohol. This latter defect can be, to a very large extent, prevented by more drastic treatment, *e.g.* by boiling the "leaves" with 20 parts instead of 16 parts by weight of caustic soda, and this treatment also considerably improves the colour of the bleached pulp, though it must be added that at the same time it reduces the yield of dry unbleached pulp from the air-dry "leaves" from 44 to 39 per cent., and the paper shrinks considerably on drying.

Specimens of the "leaves" and of bleached and unbleached paper prepared from them by the normal treatment were submitted to a firm of paper manufacturers, who were of opinion that the material would yield a paper having some of the characteristics of the papers yielded by esparto grass, straw and bamboo, but in certain respects superior to all three. The firm added, however, that in normal times these Ecdeiocolea "leaves" might not sell at a higher price than Algerian esparto grass (say £3 5s. per ton c.i.f. London), and they considered it doubtful whether paper-makers would substitute the "leaves" for esparto grass if the price were materially higher.

From the results of this investigation it is clear that these Ecdeiocolea "leaves" would form a valuable raw material for the manufacture of paper. They could not be exported from Australia to the United Kingdom in the raw state, as such materials fetch low prices, but they could be used in Australia for the manufacture of pulp and paper of high quality, either for local use or for export.

A sample of the "leaves" and a small specimen of fibre extracted from them were submitted to fibre experts. They reported that the fibre was somewhat harsh for spinning purposes, and was short, brittle and deficient in strength, and they considered that it would be of little or no commercial value.

A few experiments were made at the Imperial Institute on the extraction of fibre from the leaves. This proved to be a difficult and tedious operation, though it may be somewhat easier when fresh leaves are used. It seems unlikely that any existing fibre-extracting machinery could be used for the extraction of the fibre, and special machinery would probably have to be devised. In view of the poor quality of the fibre, as extracted by hand, it scarcely seems worth while to consider the question of special machinery, but it might be possible to prepare the fibre from the fresh leaves by a retting process, such as that used in the case of jute or flax, and it was suggested to the Australian authorities that a few pounds of fibre should be prepared in this way if possible for further examination and commercial valuation.

NEOBOUTONIA MACROCALYX TIMBER FROM THE EAST AFRICA PROTECTORATE

N. macrocalyx, Pax (Nat. Ord. Euphorbiaceae), is a medium-sized tree, which attains a height of 50-60 ft. and a diameter of 15-20 in. It is peculiar to Tropical Africa, being found in Uganda, East Africa Protectorate and German East Africa. According to information supplied to the Imperial Institute by E. Battiscombe, Conservator of Forests, East Africa Protectorate, the tree is extremely abundant in the forests of the Kikuyu Escarpment and Aberdare Mountains in that Protectorate, where it grows at an elevation of 7,000–9,000 ft. It reproduces itself readily from seed, and the young trees are fast-growing. When growing in dense formation it produces a straight bole free from branches. The timber is difficult to saw into boards or scantling on account of its "woolly" nature, and it is of little value in the building or joinery trade. The only use to which it might be put would be for making rough crates, but at present there is no demand for these in East Africa.

With a view to ascertaining the value of the timber as a source of pulp for paper-making, specimens were sent to the Imperial Institute in January 1916. The material consisted of two pieces of timber, each measuring 3 × 4 in. in cross-section and 2 ft. in length. The total weight was 6¾ lb. The wood was mostly yellowish in colour, with greyish markings. It had a "woolly" surface, and was soft and light.

Attempts to smooth the surface of the wood by planing were unsuccessful, and the freshly sawn surface, although not showing loose fibres, was very soft. The timber was free from knots.

The timber was examined at the Imperial Institute with the following results:

Moisture (in wood as received)	*per cent.*	10·5
Ash (expressed on the dried wood)	" "	1·9
Cellulose (" " ")	" "	61·0
Resin (" " ")	" "	3·5
Length of ultimate fibres		from 0·04 to 0·05 in.

The results of a series of four paper-making trials carried out at the Imperial Institute are shown in the

following table, together with corresponding figures for a sample of spruce wood examined under similar conditions, for comparison:

Experiment No.	Parts of caustic soda per 100 parts of wood.	Parts of caustic soda in 100 parts of solution.	Conditions of boiling. Hours.	Conditions of boiling. Temperature.	Yield of unbleached pulp, expressed on the timber as received.
					Per cent.
1	16	4	3½	144° C.	about 50
2	16	4	5	144° C.	
3	20	4	4	144° C.	
4	24	6	7	165° C.	46
Spruce wood	24	6	7	165° C.	42

Under the conditions of experiments 1, 2 and 3, the wood was not thoroughly broken up; but it could be converted into a workable pulp by prolonged beating. The unbleached pulp thus obtained produced a brown paper, which did not shrink on drying and was opaque. The pulp bleached easily, and yielded an almost opaque paper of good strength.

More drastic treatment, *i.e.* under the conditions of experiment 4, reduced the wood to a condition in which it was easily converted into pulp. The colour was considerably improved by this treatment, which, moreover, was only attended by a loss of about 4 per cent. in the yield of unbleached pulp. The resulting paper did not shrink on drying, and was strong and opaque. The pulp bleached easily, and yielded an opaque and almost white paper.

It is evident from the foregoing results that the wood of *N. macrocalyx* yields a good pulp, when it is treated under conditions similar to those of the "soda" process employed on the large scale for pulp manufacture from spruce and other soft woods. The ultimate fibres are rather shorter than those of spruce wood, but the pulp felts well, bleaches easily, and yields a strong paper. The yield of pulp is rather higher than in the case of spruce, and the timber should therefore form a good source of paper pulp. Before definitely recommending the timber for the manufacture of wood pulp and paper, however, it will be necessary to have a large scale trial with several tons of wood, carried out at a paper-mill.

Brachystegia Bark from Rhodesia

A sample of bark was received from Rhodesia for examination in September, 1916, together with herbarium specimens of the tree from which it was derived. The herbarium specimens were submitted to Kew, where the plant was identified as *Brachystegia Randii*, Bak. f. (Nat. Ord. Leguminosae). This is a large tree, known in the vernacular as "musasa," and is exceedingly common throughout the greater part of Mashonaland, where it forms extensive forest and woodland. The timber is soft and of little value commercially, although it is commonly used by the natives for hut building.

The sample received at the Imperial Institute consisted of ribbons of the inner bark of the plant, measuring 2 to 8 ft. in length and up to 1 in. in width. The material was mostly of a light brown colour, but a fair proportion was dark reddish-brown. A small amount of adherent outer bark was present on some of the ribbons.

A small quantity of fibre was prepared from the sample at the Imperial Institute by boiling with dilute sodium carbonate solution, but it was found to be much interlaced and therefore unsuitable for spinning purposes. It seems possible that by retting the bark ribbons a coarse fibre suitable for rope-making might be obtained, but it is unlikely that such fibre would be of much value.

The bark was examined as a paper-making material, with the following results:

Moisture in material as received	*per cent.*	11·8
Ash, expressed on the dried material	"	3·4
Cellulose, expressed on the dried material	"	43·0
Length of ultimate fibres		from 0·05 to 0·16 in.

The results of a series of three paper-making trials carried out at the Imperial Institute are shown in the following table:

Experiment No.	Parts of caustic soda per 100 parts of material.	Parts of caustic soda in 100 parts of solution.	Conditions of boiling. Hours.	Conditions of boiling. Temperature.	Yield of dry unbleached pulp, expressed on the material as received.
					Per cent.
1	16	4	4	140° C.	35·0
2	24	4	4	140° C.	32·0
3	20	4	6	154° C.	34·0

The unbleached pulp was in all three cases of dark colour, and yielded a strong, opaque, dark brown paper. The pulp bleached easily and quickly and yielded a white opaque paper, which did not shrink on drying and was of good quality.

It seems unlikely that a fibre of value for textile or cordage purposes could be prepared from this Brachystegia bark, and the latter is more likely to be of use for paper making. The bark would only yield about 33 per cent. of unbleached pulp, which is distinctly low for a paper-making material, but the pulp is of good quality, and the bark would no doubt be saleable if offered in large and regular quantities. The export of the bark from Rhodesia is, however, not likely to prove remunerative as it would probably not realise more than £5 per ton in normal times in the United Kingdom, in competition with baobab bark, which contains 60 per cent. of cellulose and is worth £7 to £8 per ton. It would therefore be necessary to convert it into "half-stuff" in Rhodesia and ship it in this form to Europe.

For the manufacture of "half-stuff" soda and other chemicals would be required, as well as considerable supplies of fuel and water, and in view of this it is doubtful whether a pulp industry would be remunerative in Rhodesia. An important point in this connection is the quantity of the bark likely to be available and the cost of collection; but information on these points is not yet available.

FIBRES FROM VARIOUS SOURCES

In the following pages an account is given of the results of examination of a number of fibres which have been investigated at the Imperial Institute in recent years.

Jute from Egypt

A sample of jute obtained from plants grown from Indian seed in the Horticultural Gardens, Cairo, was received in August 1916. It had been prepared by a special process. The fibre varied greatly in colour, being

mostly light reddish-brown, with a small portion of a buff tint. It was soft, clean and well-prepared, but on the whole had little lustre. The strength was rather irregular, but on the whole good. The length of the fibres varied from 5 to 9 ft., being mostly from 6 to 7 ft.

The sample was submitted to chemical examination; with the results given in the following table, which shows also the corresponding figures obtained for a sample of "extra fine" Indian jute:

	Present sample. *Per cent.*	"Extra fine" Indian jute. *Per cent.*
Moisture	11·1	9·6
Ash	2·7	0·7
α-Hydrolysis, loss	4·4	9·1
β-Hydrolysis, loss	7·6	13·1
Acid purification, loss	4·6	—
Loss on washing in water	2·0[1]	—
Cellulose	76·8	77·7

[1] *Containing* 0·75 *per cent. of alkali calculated as sodium carbonate* (Na_2CO_3).

The fibre was valued by a firm of brokers in London at £36 to £37 per ton c.i.f. London, with Calcutta jute at £41 and "Bimlipatam jute" (*Hibiscus cannabinus*) at £35 per ton (December 1916). The brokers considered that the material would be saleable in large quantities.

The low figures for loss on hydrolysis are due to the special treatment to which this fibre had been submitted in the course of preparation. The fibre had not been sufficiently washed in clean water after preparation, and still contained some alkali which might be objected to by manufacturers.

The fibre was inferior in colour and lustre to Indian jute of fair quality prepared by retting.

Sida rhombifolia Fibre from South Africa

A small sample of *Sida rhombifolia* fibre from Swaziland, where the plant is known as "vivane," was received at the Imperial Institute early in 1916. It consisted of nearly white, lustrous fibre, well cleaned and prepared, but somewhat harsh. It was of good strength, and about 2 ft. in length.

The sample was too small for the purpose of chemical examination and technical trial.

Fibre of similar quality to this sample, but measuring 4 ft. or more in length, would probably realise a price about £3 or £4 below that of "first native marks" Calcutta jute, which at the date of the report (February 1916) was selling in London at £32 per ton. A small consignment of Sida fibre from India previously examined at the Imperial Institute was sold in London in 1913 at £36 per ton, with "first native marks" Calcutta jute at £35 10s. to £36 per ton (see this BULLETIN, 1914, 12, 36).

The sample from Swaziland was of good quality, but not so fine and silky or so long in staple as the Sida fibre from India referred to above.

In response to a request from the Imperial Institute a larger sample of this fibre was received in June 1916 for detailed examination, technical trial and valuation.

This sample consisted of harsh fibre, mostly matted and gummy, not well-prepared and of little lustre. The material was greyish-cream in colour, with a few small portions of a greyish tinge. Some adherent outer bark was present. The strength was irregular, but on the whole fairly good. The length varied from 2 to 6 ft., being mostly from 3 to 4 ft.

It was examined chemically with the following results compared with a sample of *S. rhombifolia* fibre from India (*loc. cit.*):

	Present sample. *Per cent.*	*S. rhombifolia* from India. *Per cent.*
Moisture	11·6	9·5
Ash	2·3	0·4
α-Hydrolysis, loss	13·2	7·3
β-Hydrolysis, loss	19·6	10·4
Acid purification, loss	5·9	0·8
Loss on washing in water	4·6	—
Cellulose	70·5	75·5

The fibre was valued by brokers at £17 to £18 per ton c.i.f. London, with Calcutta jute at £28 per ton (July 1916). It was considered that such fibre would be saleable for mixing with jute when the latter is obtainable only at high prices.

This fibre appeared to be under-retted and insufficiently washed. It was much inferior in appearance and quality to the small sample from Swaziland previously examined and the sample from India referred to above. In view of the superior appearance of the material previously examined it was recommended that experiments in retting the fibre for varying periods should be carried out, and that the fibre so prepared should be submitted to the Imperial Institute for examination and valuation.

Hibiscus cannabinus Fibre from Rhodesia

A sample of *Hibiscus cannabinus* fibre prepared in Rhodesia, where the plant grows as a weed on cultivated land, was received for examination in January 1916. It consisted of fine, somewhat harsh fibre of fair lustre. The colour was uneven, parts of the sample being pale brown and others light grey, whilst a small proportion was greenish-yellow. The fibre was gummy in parts and had not been well cleaned and prepared. The retting appeared to have been effected somewhat unevenly. The fibre was of irregular strength and the length varied from 4 to 6 ft., being mainly about 5 ft.

The results of chemical examination of the fibre are shown in the following table, compared with a commercial sample of Bimlipatam jute:

	Present sample. *Per cent.*	"Bimlipatam jute." *Per cent.*
Moisture	9·4	12·5
Ash	1·3	1·3
α-Hydrolysis, loss	17·3	11·8
β-Hydrolysis, loss	18·3	15·1
Acid purification, loss	4·9	—
Loss on washing in water	2·6	—
Cellulose	71·2	75·4

The sample was valued by merchants in London at about £27 per ton (May 1916), with "First Marks" Calcutta jute at £32 per ton.

The comparatively large losses on hydrolysis, acid purification and on washing in water, together with the low percentage of cellulose, show that this sample was

of somewhat poor quality owing to imperfect retting and washing. The fibre was inferior in colour, softness and general appearance to fair quality "Bimlipatam jute," which is prepared from *H. cannabinus* in India, and usually realises a price about £2 to £3 per ton below that of "First Marks" Calcutta jute.

The firm who valued the sample stated that the fibre should be quite suitable for mixing with the lower grades of Calcutta jute, and that if it were better prepared it should find a good market in the United Kingdom.

In this connection it must be borne in mind that the price quoted above for "First Marks" Calcutta jute is abnormally high owing to the war, the price in normal times being only £15 to £20 per ton. The price of this Hibiscus fibre under normal conditions would, of course, be correspondingly reduced.

The poor quality of this sample, and of previous samples of *Hibiscus* fibre from Rhodesia (cf. this BULLETIN, 1915, **13**, 22), appears to be due to lack of experience of the methods of preparation. The present sample was of uneven quality and colour, parts being gummy and obviously under-retted. To obtain the best results the progress of the retting action should be observed from time to time by removing a few stems from different parts of the pile and testing the ease with which the fibre ribbons may be separated from the stems and from adherent bark. It is essential also that care should be taken throughout to keep the fibres from becoming tangled.

Hibiscus cannabinus Fibre from Egypt

A sample of *Hibiscus cannabinus* fibre prepared from the native "til" plant by a special process was received in August 1916. The fibre was of a buff colour, clean and well prepared. It was fairly soft, but showed some red stains, and was practically devoid of lustre. It was of fairly good strength and varied in length from 2 ft. 6 in. to 5 ft. 6 in., being mostly from 3 ft. to 3 ft. 6 in.

The fibre was examined chemically with the following results, compared with *H. cannabinus* fibre from Rhodesia and "extra fine" Indian jute :

	Present sample. Per cent.	H. cannabinus from Rhodesia. Per cent.	"Extra fine" Indian jute. Per cent.
Moisture	8·5	9·6	9·6
Ash	1·6	1·2	0·7
α-Hydrolysis, loss	6·1	11·6	9·1
β-Hydrolysis, loss	9·3	15·2	13·1
Acid purification, loss	2·7	0·8	—
Loss on washing in water	2·0 [1]	—	—
Cellulose	79·9	74·3	77·7

[1] *Including 1 per cent. of alkali expressed as sodium carbonate (Na_2CO_3).*

The fibre was valued by brokers in London at about £30 per ton, c.i.f. London, with Calcutta jute at £41 and "Bimlipatam jute" (*H. cannabinus*) at £35 per ton (December 1916).

The low figures for loss on hydrolysis and the high percentage of cellulose are due to the special treatment to which this fibre had been submitted in the course of preparation. The fibre had not been sufficiently washed, and contained alkali.

The fibre was inferior in appearance, and especially in lustre, to well-prepared Hibiscus fibre obtained by retting.

Hibiscus Fibre from Nyasaland

Two samples of Hibiscus fibre prepared from wild plants were received from Nyasaland in November 1915. They were examined with the following results:

No. 1.—This sample consisted of rather harsh fibre, of poor lustre, and varying in colour from cream to pale reddish-brown. The material was clean and fairly well prepared on the whole, but rather gummy in parts. It was of very good strength, and was mostly from 2 to 3 ft. in length, but some shorter fibre was also present.

The fibre was examined with the following results compared with Hibiscus fibre from the Sudan and "extra fine" Indian jute:

	Present sample. Per cent.	Hibiscus fibre from the Sudan. Per cent.	"Extra fine" Indian jute. Per cent.
Moisture	10·8	8·2	9·6
Ash	3·2	0·7	0·7
α-Hydrolysis, loss	17·9	8·6	9·1
β-Hydrolysis, loss	21·7	13·4	13·1
Acid purification, loss	8·0	—	—
Loss on washing in water	3·6	—	—
Cellulose	71·6	77·8	77·7

The material was valued at £37 per ton, c.i.f. London (September 1916), with medium quality Indian jute ("first native marks") at £33 to £34, finest Indian jute ("Green D") at £45, and "Bimlipatam jute" (*Hibiscus cannabinus*) at about £27 per ton.

No. 2.—This fibre was reddish-brown in colour, harsh, and practically devoid of lustre. It was not well prepared, being gummy and containing some adherent bark. The ends had the appearance of having been cut. It was of uneven strength, and very weak in parts. The length was mostly between 2 and 3 ft., with a fair proportion of shorter fibre.

The fibre gave the following results on chemical examination compared with Hibiscus fibre from the Sudan and "extra fine" Indian jute:

	Present sample.	Hibiscus fibre from the Sudan.	"Extra fine" Indian jute.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·3	8·2	9·6
Ash	2·6	0·7	0·7
α-Hydrolysis	16·2	8·6	9·1
β-Hydrolysis, loss	22·1	13·4	13·1
Acid purification, loss	6·7	—	—
Loss on washing in water	7·6	—	—
Cellulose	68·8	77·8	77·7

This sample was valued at £30 per ton, c.i.f. London (September 1916). The prices of Indian and Bimlipatam jutes on this date are given above.

In the case of both these samples the losses on acid purification, hydrolysis and washing in water were high, and the amount of cellulose in the fibre was low. The material had apparently been insufficiently cleaned and prepared. Sample No. 2 was distinctly inferior to No. 1, especially in strength, and the poor strength of parts of the former fibre suggests that the fibre had been damaged by being baled in a moist condition.

Nettle Fibre from India

The sample of nettle fibre from India which is the subject of this report was forwarded to the Imperial Institute by the Fibre Expert to the Government of Bengal in March 1916.

The sample consisted of uneven, very tangled fibre, varying in colour from brown to pale buff with many green portions. The fibre, which was stated to have been prepared merely by mechanical treatment, retained most of the gummy matter, and was coated with bark. The length of staple varied from 2 to 5 ft., but was mostly about 3 ft. 6 in. The individual fibres were very fine in diameter, and appeared to be weaker than either flax or ramie.

A portion of the sample was cleaned and degummed at the Imperial Institute. The cleaned fibre was moderately lustrous, and was found to be made up of ultimate fibres measuring mostly from 4 to 5 in. in length and from about 0·002 to 0·004 in. in diameter. The fibre was thus similar to ramie and certain other nettle fibres.

Samples of the crude fibre as received, and of the cleaned and degummed material, were submitted to brokers in London and Dundee, who reported on them as follows:

(1) The London brokers stated that nettle fibre of this kind would in any case require to be properly degummed before being used as a substitute either for flax or ramie, and that this would add considerably to the cost of production. They pointed out, moreover, that the fibre was brittle and of irregular strength, being weaker than flax and very considerably weaker than ramie. The firm were therefore of opinion that the material would hardly be a suitable substitute for either flax or ramie, but that it would be more suitable for mixing with jute if it could be prepared at a sufficiently low price. They regarded the cleaned, degummed fibre as worth probably from £35 to £40 per ton in London (June 1916).

(2) The Dundee brokers reported that the material in the uncleaned state could only be used for a heavy jute rove, and that its value in that condition would not exceed £15 per ton. They considered that the cleaned and degummed fibre could be used for similar purposes to the lower qualities of Italian hemps, but that it would not have sufficient spinning quality to be used as a flax substitute. The firm valued the cleaned and degummed fibre at from £26 to £30 per ton (June 1916).

This fibre in the crude state would almost certainly

be unsaleable, owing to its gummy condition and the presence of bark; but, if it were possible to prepare the fibre in India in a clean condition by retting, there seems to be no reason why it should not be used in admixture with jute or hemp for the manufacture of coarse textiles. If, however, it is not found possible to ret the fibre in India it might perhaps be saleable in the form of clean bark ribbons, if the outer bark could be removed by scraping in a manner similar to that by which China grass (ramie) ribbons are prepared for the European market.

Sisal Hemp from Rhodesia

The sample of Sisal hemp dealt with in this report was prepared from plants grown at the Experimental Gardens, Chilanga, Northern Rhodesia. The Sisal was planted in April 1913 and the leaves decorticated by hand in May 1916. So far, the fibre has not been produced on a commercial scale in Rhodesia.

The sample, which was received at the Imperial Institute in January 1917, consisted of lustrous fibre, of pale cream colour, and very well cleaned and prepared. It was of very good strength and varied in length from 2 ft. to 3 ft. 4 in., being mostly from 2 ft. 6 in. to 3 ft.

The fibre was submitted to chemical examination, with the following results, compared with Sisal hemp from East Africa:

	Present sample. *Per cent.*	Sisal hemp from East Africa. *Per cent.*
Moisture	7·4	9·6
Ash	0·6	0·8
α-Hydrolysis, loss	9·3	11·3
β-Hydrolysis, loss	11·7	14·8
Acid purification, loss	1·1	2·1
Loss on washing in water	1·3	—
Cellulose	80·5	77·4

The fibre was valued at £65 per ton in London (February 1917) with British East African Sisal at £67 to £70 per ton.

This fibre was of exceptionally good quality, and was stated by the brokers to whom it was submitted for valuation to be one of the best-prepared samples of Sisal hemp they had seen. It was stated that a slightly greater

length of staple would enhance the value of the fibre to the extent of from £2 to £3 per ton.

FURCRÆA FIBRE FROM SOUTHERN RHODESIA

The sample of Furcræa fibre from Southern Rhodesia dealt with in this report was received at the Imperial Institute in June 1915. It consisted of moderately lustrous fibre, fairly well cleaned and prepared, and varying in colour from cream to pale buff. A fair proportion of adherent pith was present in the sample. The strength was fairly good, but rather uneven, and the length varied from 3 to 8 ft., being mostly from 5 ft. to 5 ft. 6 in.

The fibre was examined chemically with the following results, compared with previous samples of Furcræa fibre from Rhodesia (see this BULLETIN, 1915, 13, 21):

	Present sample.	Previous samples from Rhodesia.	
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·1	11·5	10·1
Ash	1·6	1·5	1·4
α-Hydrolysis, loss	14·8	12·7	14·0
β-Hydrolysis, loss	17·8	17·7	16·4
Acid purification, loss	4·4	0·4	1·7
Cellulose	72·0	79·3	77·6

The sample was valued at about £34 to £35 per ton in London (July 1915) by merchants, who stated that similar material would be saleable in large quantities.

The results of the chemical examination show that this sample was inferior to the Furcræa fibre from Rhodesia previously examined at the Imperial Institute, on account of the somewhat greater losses on hydrolysis and acid purification, aud the lower percentage of cellulose. The rather high losses on acid purification and hydrolysis indicate that the fibre had not been sufficiently washed.

Fibre of better quality could be obtained by more thorough washing and removal of the pith by brushing, and also by sorting into bundles of uniform length. It was also suggested that efforts should be made to obtain the fibre as nearly white as possible.

The fibre, it may be mentioned, was considerably coarser than the Furcræa fibre (*Furcraea gigantea*) produced in Mauritius.

Furcraea gigantea Fibre from South Africa

A sample of *Furcraea gigantea* fibre from Winkle Spruit Experimental Farm was received at the Imperial Institute in September 1915. The fibre was of dull appearance, and cream to very pale buff in colour. It was insufficiently cleaned and prepared, a quantity of pith, leaf epidermis and gummy matter being present. It was of good strength, and varied in length from 5 ft. to 7 ft. 6 in., being mostly about 6 ft. It gave the following results on chemical examination:

	Per cent.
Moisture	9·9
Ash	1·3
α-Hydrolysis, loss	13·8
β-Hydrolysis, loss	16·3
Acid purification, loss	2·8
Cellulose	72·7

The material was submitted to a firm of merchants, who valued it at £20 to £21 per ton, c.i.f. London (October 1915), adding that, if well cleaned and prepared, it would probably have been worth £32 to £33 per ton.

This fibre was well grown and of good length and strength, but, as the results of examination show, it had been badly cleaned and prepared. Consignments represented by the present sample would not be very saleable on the London market. By more thorough cleaning, however, the fibre could be obtained free from extraneous matter and of greatly improved lustre and general appearance, and it would then find a ready market.

Asclepias fruticosa Fibre from South Africa

According to the Chief of the Division of Botany, Union Department of Agriculture, *Asclepias fruticosa*, which is known locally as "melkbosch" and is common and widely distributed throughout South Africa, is especially abundant in the neighbourhood of Pretoria and Johannesburg, and large quantities could be collected if necessary.

Two samples of fibre prepared from the stems of this plant were received at the Imperial Institute from South Africa in November 1915. Information was requested as to

whether these fibres, which are non-lignified, possess any special value for the manufacture of explosives.

Both samples of fibre were prepared at the Botanical Laboratories, Pretoria, No. 1 being obtained from plants collected in August and No. 2 from plants collected in October when in flower.

No. 1.—This consisted of rather harsh fibre of poor lustre, nearly white with a greenish tinge. The fibre was clean but not well prepared, a good deal of bark being present. The strength was fair. The length of the staple varied from 14 to 30 in., being mostly from 21 to 22 in.

No. 2.—This sample closely resembled No. 1 in general appearance. The length of staple varied from 16 to 26 in. and was mostly about 20 in.

The samples were submitted to chemical examination with the following results:

	No. 1. *Per cent.*	No. 2. *Per cent.*
Moisture	8·0	8·4
Ash	1·5	1·4
α-Hydrolysis, loss	13·1	13·0
β-Hydrolysis, loss	16·2	15·4
Acid purification, loss	7·0	7·0
Cellulose	82·0	81·5
Gain on nitration	51·5	53·5

The richness of this Asclepias fibre in cellulose and the large increase of weight on nitration confirmed the results of previous investigations of this variety of fibre at the Imperial Institute, and indicated that the material might be useful for the manufacture of explosives (cf. this BULLETIN, 1905, 3, 316, and *Selected Reports from the Scientific and Technical Department, Imperial Institute, Part I, Fibres, Colonial Reports, Misc. Ser.*, No. 58 [Cd. 4588, 1909], p. 50).

The samples were submitted for valuation to a firm of merchants in London, who valued No. 1 at £37 to £38 and No. 2 at £32 to £33 per ton (March 1915). They based this valuation on a comparison with Sisal hemp which, if not less than 3½ to 4 ft. in length, at that date realised about £50 per ton.

The firm added that it was not advisable to cut any fibre plants under 3 to 3½ ft. in length, as spinners of hard fibres object to using any material measuring under 3 ft.

The firm also expressed a wish to take charge of any consignment of this Asclepias fibre which may be shipped to the United Kingdom. The Imperial Institute has asked the Union Government as to the prospects of the material being exported in commercial quantities and for the names and addresses of possible exporters, but this information has not yet been received.

Kapok from the Sudan

A sample of kapok obtained from trees planted some years ago at Mongalla, Sudan, was received at the Imperial Institute in December 1916.

The sample consisted of clean, soft, lustrous, resilient kapok of cream colour. A small proportion of pieces of the inner part of the pods was present. The fibre was of normal strength for kapok, and had a length of staple of from 0·7 to 1·0 in.; the diameter varied from 0·0007 to 0·0012 in.

A sample of the material cleaned and freed from extraneous matter at the Imperial Institute was submitted to brokers in London, who stated that the floss had a resiliency equal to that of Java kapok. They assigned a nominal value to the material of 1*s.* per lb. on spot (January 1917).

This floss was of excellent quality, and similar material, if shipped clean and free from extraneous matter, should realise the current market price of good quality kapok, for which there is a large demand at present.

Kapok from Togoland

Kapok received special attention from the late German authorities in Togoland, and seed was distributed to the natives in large quantities, especially in the districts of Sokode-Bassari, Kete-Kratschi and Mangu. In 1913, 9 tons of kapok, valued at £472, were exported.

A small bale of kapok from Togoland was received at the Imperial Institute from the Chief Commissioner, Northern Territories, Gold Coast, in August 1916. The material consisted of very soft, lustrous, resilient fibre of a dark cream colour. It was similar in all respects to the

kapok of commerce (*Eriodendron anfractuosum*), which is mainly imported from Java.

The diameter of the fibres varied from 0·0007 to 0·0010 in., being mostly 0·0008 in., and the length of staple varied from 0·7 to 1·0 in. The fibres were weak, but of normal strength for kapok.

The kapok was submitted to a firm of brokers for sale on behalf of the Imperial Institute. The best offer received was 7*d.* per lb., and the bale was accordingly sold at this price in London (October 1916).

There is little doubt that consignments of kapok of this quality would always be readily saleable in the United Kingdom at good prices. The price of 7*d.* per lb. obtained for the present consignment may be regarded as satisfactory, but it would probably have been higher if the quantity of material had not been so small.

As there is a ready market for this material in London for upholstery and other purposes, it seems desirable that an effort should be made to develop the industry in Togoland. Large quantities of kapok are now being used for the manufacture of life-buoys and life-saving jackets and mattresses, but for these purposes the Board of Trade regulations specify that *Java* kapok should be employed. It was suggested to the Gold Coast authorities that if fairly large supplies of kapok from Togoland are likely to be available, a sample should be forwarded to the Imperial Institute, in order to ascertain whether it complies sufficiently with the Board of Trade requirements to be acceptable as a substitute for the Java product. Information has also been requested as to the quantity of kapok now available for sale, and the amounts likely to be available in the near future.

It was further pointed out that it would be advisable to have the remainder of the kapok now available shipped to the United Kingdom for sale, and to encourage the natives to collect and clean further quantities for export.

A few years ago, it was reported that the Germans had introduced machinery into Togoland for freeing kapok from the seeds, but so far no information is available as to how the present consignment was cleaned, whether by machinery

or by some primitive native method. According to the Report of the German Colonial Office on Togoland for 1912–13, attempts to gin the product by machinery had not up to then given satisfactory results.

Asclepias fruticosa Floss from South Africa

An account of the results of examination at the Imperial Institute of the floss of *A. fruticosa* from the Transvaal was given in this Bulletin (1913, 11, 81). A further sample was received in June 1916. It consisted of clean, very soft and lustrous floss varying in tint from pale yellow to cream. The material was inferior to kapok in resiliency.

The fibres of the floss measured from 0·6 to 0·9 in. in length, with a diameter of from 0·0005 to 0·0011 in. The strength was fairly good with regard to longitudinal stress; but the fibres were somewhat brittle, as is usually the case with such products. Microscopical examination showed that the fibres were quite smooth, and had very thin walls with a wide channel in the centre.

Samples of the floss were submitted to a firm of brokers and to manufacturers of upholstery materials, who reported as follows:

(*a*) The brokers regarded the material as similar to the floss known in commerce as "Akund." They stated that there is only a limited consumption of the product in the United Kingdom, where kapok is preferred, and that before the war most of the "Akund" went to Germany. The firm considered the nominal value of the material to be about 5½*d.* or possibly 6*d.* per lb. in London (July 1916).

(*b*) The manufacturers stated that the floss was of low quality and that there would be less demand for it than for kapok. They valued the material, if marketed free from seed like the sample submitted to them, at from £25 to £30 per ton (*i.e.* about 2¾*d.* to 3¼*d.* per lb.), c.i.f. London (July 1916).

As already stated, there has recently been a large demand for kapok for use in stuffing life-belts and other life-saving devices. A sample of this floss was therefore submitted to a manufacturer of such appliances. He stated that the material generally resembled akund, kapok and bombax

floss, but on preliminary examination appeared to be much inferior to them in buoyancy. It is desirable, however, to make further trials of the material, and for this purpose a large sample of the floss has been requested.

Seed Hairs of *Ipomoea albivenia* from South Africa

Ipomoea albivenia, Sweet, is an evergreen climber belonging to the Natural Order Convolvulaceæ, and is closely allied to the sweet potato. A sample of the seed hairs of this plant was forwarded to the Imperial Institute by the Trades Commissioner for the Union of South Africa in August 1916. It was stated that large quantities of the material were understood to be available in Natal and Zululand, and could be collected cheaply by natives. The product is known locally as Kaffir or Natal cotton.

The sample consisted of seed with adherent hairs of dark cream colour, resembling harsh, unginned cotton. The fibres had little lustre, and were weak and brittle.

The seeds, which were easily separated from the seed hairs, were devoid of adherent fuzz, and were of a pale brown colour. They were triangular in cross section, and measured about 0·3 in. in length.

The yield of seed hairs on ginning the material was 31 per cent., the yield per 100 seeds being 4·6 grams.

The fibres measured 0·0009 to 0·0023 in. in diameter, with an average of 0·0015 in. Cotton has a diameter of 0·0004 to 0·0011 in. with an average of 0·0008 in. The length of staple varied from 0·6 to 1·4 in., being mostly from 1·0 to 1·1 in. Microscopical examination showed that the fibres were somewhat similar in general appearance to those of cotton, but they were thin-walled and were not generally twisted as is the case with cotton.

Comparative tests showed that the raw Ipomœa fibre was much more absorbent than untreated cotton, but less so than prepared "absorbent cotton wool," and that after being bleached it was still slightly less absorbent than the latter material. The following table gives the number of grams of water absorbed by 1 gram of the material in each case:

	Cotton wool. Grams.	Seed hairs of *Ipomoea albivenia.* Grams.
Unbleached	·35	16
Bleached, absorbent	24[1]	21

[1] *The material used for this test was "absorbent cotton wool," such as is used for surgical dressings.*

The seed hairs of *I. albivenia* would probably be unsuitable for spinning, as the fibres lack the twist characteristic of cotton, and are very weak. The weakness of the fibres would probably cause difficulty in "carding," and the fibre would yield yarn of poor strength.

If obtainable in large enough quantities at a low price the seed hairs might possibly be of use as a stuffing material in upholstery. The material is, however, much less resilient than kapok, and would therefore be less valuable.

These seed hairs might find an outlet for the production of nitro-cellulose, but experiments made at the Imperial Institute on a previous sample of the material showed that it contained much less cellulose than cotton (77·3 against 95 to 96·5 per cent.), and it would therefore be inferior to cotton for this purpose.

The raw fibre would not be sufficiently absorbent for use in surgical swabs, and the chemical and mechanical methods usually employed in preparing cotton for this purpose would cause a good deal of waste, and the product would be much inferior to absorbent cotton.

On the whole this is not a promising material. The sample now reported on was, however, too small for detailed investigation, and a larger sample has been asked for in order to investigate fully its value for some of the purposes suggested above.

COTTON CULTIVATION IN AUSTRALIA

The climatic conditions of large areas in the warmer parts of Australia are well adapted for the growth of cotton. At the present time, however, it is cultivated to only a small extent in Queensland and the Northern Territory. The chief difficulty is the high cost of picking, due partly to inexperience, but mainly to the high rate of wages. It is thought that the labour difficulty might be overcome by growing the crop in small areas only, say about 10 acres

each, which could be picked by a family of four persons without extra help. Efforts have also been made to obtain a satisfactory cotton-picking machine, but so far without success. Black labour (aboriginal) is employed only on one estate, in North Queensland, where the crop is grown on the plantation system; elsewhere cotton is cultivated as a subsidiary crop by white labour in areas varying from 5 to 30 acres.

Cotton was first grown in Queensland in 1852, in which year 70 bales and 18 bags were shipped to England. At the time of the American civil war, and for a few years afterwards, when cotton prices in England were very high, a large area was cultivated in Queensland, the maximum export being 2,500,000 lb. of ginned cotton in 1871. The increase in American production after the war led to a fall in price to the normal level, and the Queensland industry practically died out. An attempt to revive it was made in 1890, when a cotton mill was started at Ipswich, but this closed in 1897, when cotton-growing ceased. A few years later the Government imported seed from America and Egypt, and distributed it free to growers with a view to encouraging cultivation, but the area devoted to the crop since then has never been large, the maximum during the ten years 1906-1915 being 605 acres in 1911, when the production amounted to 186,894 lb., valued at £4,672. By 1915 the area had fallen to 72 acres, and the production to 12,238 lb., of value £306. In 1913 the British Cotton Growing Association agreed to assist the industry by making a grant, by provision of seed for experiment, by undertaking the sale of the cotton and guaranteeing a minimum price of 6½*d.* per lb. for all annual-grown cotton. More recently a Munitions Cotton League was formed in Queensland to stimulate the production of cotton, particularly for the manufacture of explosives. The Government distributed seed to 300 farmers and guaranteed to purchase seed-cotton at 1¾*d.* per lb. As a result 800 acres were planted in 1916. Sufficient American cotton seed is being imported to plant an additional area of 1,000 acres next season.

Of the other parts of Australia, the Northern Territory grows very little cotton, 15 acres being under the crop in

1912-13; parts of Western Australia and New South Wales are also suitable for the crop, but so far it has not been produced on a commercial scale.

Samples of cotton grown in Queensland, Western Australia and New South Wales have been received at the Imperial Institute in recent years, and the results of their examination are given in the following pages.

Queensland

One sample of cotton was received from Queensland in 1911 and two further samples in 1912. The two later samples were grown from Egyptian seed and represented the first year's crop—that is, the plants had not been acclimatised.

No. 1.—The variety of this cotton was not stated. The lint was clean, fairly lustrous, slightly harsh, white and free from stains; the yield on ginning was 34·15 per cent. and the yield per 100 seeds 7·0 grams. The seeds were fairly large, smooth and brown, each bearing a tuft of down and a spike at the pointed end.

The cotton was of poor strength and varied in length from 0·7 to 1·3 in., being mostly from 0·9 to 1·1 in.

The ginned material was valued at from 6·80*d.* to 6·90*d.* per lb., with "middling" American at 6·46*d.* per lb.

This cotton was of good colour, rather harsh and coarse, and decidedly weak. It was classed by brokers as of "barely good middling" grade.

No. 2.—This was stated to be an Egyptian variety, probably "Afifi." The lint was clean, soft and fine, of fairly good lustre and of rather irregular colour, varying from very pale reddish-brown to almost white, with a few dark brown or yellowish stains. The yield of lint on ginning was about 19·4 per cent. and the yield per 100 seeds about 2·52 grams. The seeds were of medium size and of dark chocolate colour, almost black. A few seeds had a small tuft of white or green fuzz at the pointed end.

The strength of this cotton was fairly good, but the length was rather irregular, ranging from 1·1 to 2·1 in.

The ginned cotton was valued at 12·50*d.* per lb., with "choice" Georgia Sea Island cotton at 13*d.* per lb. and "fancy" Florida Sea Island at 14*d.* per lb.

This cotton did not possess the characters of Egyptian Mitafifi, but resembled the Sea Island variety. It was of satisfactory quality apart from its rather uneven colour and irregular length. These defects could probably be remedied by seed selection and greater care in cultivation.

No. 3. "*Nubari.*"—The lint of this sample was clean, soft and fine, of moderately good lustre, but of uneven colour, varying from pale reddish-brown to cream, with occasional rusty-brown stains. The yield of lint on ginning was about 27·5 per cent. and the yield per 100 seeds about 4·01 grams. The seeds were of medium size and mostly of dark chocolate colour, with a small tuft of white fuzz at the pointed end. Several seeds bore patches of white fuzz, and many yellow or partly yellow unripe seeds were present.

This cotton was of poor strength, much immature fibre being present. The length varied from 1·1 to 1·7 in. and was mostly from 1·3 to 1·5 in. Short weak fibres were also present.

The ginned cotton was valued at 9·25*d.* per lb., with "good fair" brown Egyptian at 9·80*d.* per lb. and "good fair" Nubari at 10·20*d.* per lb.

This cotton was inferior to ordinary Egyptian Nubari in length and strength, but would nevertheless be readily saleable. Some of the cotton did not seem to have ripened properly, and in consequence a good deal of short weak fibre was present which would cause waste in manufacture.

As in the case of sample No. 2, this cotton could be improved by careful methods of cultivation and seed selection.

Western Australia

Two samples of seed-cotton produced experimentally in Western Australia were received in April 1912.

No. 1. "*Durango.*"—The lint of this sample was clean, lustrous, soft, white, and free from stains. The yield of lint on ginning was about 40 per cent. and the yield per 100 seeds about 7·9 grams.

The seeds were of medium size and coated with a brownish fuzz.

This cotton was of rather poor strength and its length varied from 0·9 to 1·5 in., being mostly from 1·2 to 1·4 in.

The fibres had a diameter of from 0·0006 to 0·0010 in., the average being 0·00076 in.; they exhibited a good twist and were fully mature.

The ginned cotton was valued in Liverpool at 9·00*d.* per lb., with "middling" American at 6·37*d.* per lb. and "good" Egyptian Abassi at 11*d.* per lb.

This cotton was of an improved American type and of excellent quality. The yield of lint on ginning was higher than is usual for this kind of cotton.

No. 2. "*Sea Island Cotton.*"—The lint in this sample was clean, fairly lustrous, soft, of pale cream colour and free from stains. The yield of lint on ginning was about 32·5 per cent., the yield per 100 seeds being about 5·4 grams.

The seeds were of medium size, mostly dark brown and tufted with down at the pointed end, a few being completely covered with a brownish fuzz. It may be mentioned that pure Sea Island cotton seed is free from down or fuzz.

The strength of the cotton was rather poor and somewhat irregular. The length varied from 1·0 to 1·9 in. and was mostly from 1·5 to 1·7 in. The diameter of the fibres ranged from 0·0006 to 0·0011 in., the average being 0·00081 in. The average diameter of Sea Island cotton is usually about 0·00064 in. Most of the fibres showed a good twist and were fully mature.

The ginned cotton was valued in Liverpool at 13*d.* per lb., with "choice" Georgia Sea Island at 12½*d.* per lb. and "extra fine" Sea Island at 19½*d.* per lb.

This cotton differed a good deal from ordinary Sea Island cotton, being very much coarser, but such cotton, if produced in commercial quantities, should be readily saleable.

Three further samples of seed-cotton were received for examination in July 1914. They were stated to have been grown under natural conditions without irrigation, on two-year-old trees, at Derby, in the north-western portion of Western Australia.

No. 3. "*Russell.*"—The lint of this sample was clean, rather harsh, lustrous, white, almost free from stains, but slightly "leafy." The seeds were large, covered with long, white, brownish or greenish fuzz; some of the seeds had been attacked by insects.

The cotton was of fairly good strength and varied in length from 0·6 to 1·2 in., being mostly from 0·8 to 1·0 in.

The ginned cotton was valued at from 5·91*d.* to 6·16*d.* per lb., with "middling American futures" at 6·12*d.* per lb.

This cotton was rather shorter and harsher than is usual for cotton of the Russell variety.

No. 4. *Long Stapled* (*Upland*).—The lint was clean, fairly soft, lustrous and pale cream-coloured; it showed occasional yellowish-brown stains and was slightly "leafy." The seeds were large and covered with long greyish or greenish fuzz; many had been attacked by insects.

The cotton was of fair strength and varied in length from 1·0 to 1·6 in., being mostly from 1·3 to 1·5 in.

The ginned cotton was valued at from 6·66*d.* to 6·91*d.* per lb., with "middling American futures" at 6·12*d.* per lb.

This cotton was of satisfactory quality, but was rather weaker than ordinary American cotton and slightly stained.

No. 5. "*Sunflower.*"—The lint of this sample was clean, soft, lustrous and white; a few yellowish-brown stains were present. The seeds were large and mostly covered with white or brownish fuzz, but some brown seeds without fuzz were also present; many of the seeds had been attacked by insects.

The strength of the cotton was a little irregular, but on the whole was fairly good. The length varied from 1·0 to 1·6 in., being mostly from 1·2 to 1·4 in.

The ginned cotton was valued at 6·91*d.* per lb., with "middling American futures" at 6·12*d.* per lb.

This cotton was a little deficient in strength, but was regarded by commercial experts as of better quality than Nos. 3 and 4.

A large proportion of the seeds of Nos. 3 and 5 had been attacked. One or more living larvæ were found in each sample, and these were identified as *Gelechia gossypiella*, the pink boll-worm, an insect which has caused considerable damage in Egypt. It is of great importance that measures should be taken to destroy this pest, and an account of the most suitable methods will be found in this BULLETIN (1914, **12**, 312).

New South Wales

Cotton-growing experiments were conducted in New South Wales in 1914, when seed of different varieties was distributed by the Department of Agriculture to farmers in various parts of the State, and the crop was grown under irrigation at the Department's Experiment Farm at Yanco. The best results obtained, so far as yield is concerned, were with the "Russell's Big Boll" variety, grown from Queensland seed, which gave a yield of 620 lb. of seed-cotton per acre. Specimens of cotton grown at the Yanco Experiment Farm and also by private farmers were received for examination at the Imperial Institute in March 1916.

No. 1. "*Russell's Big Boll.*"—Grown at Nimbin. This sample consisted of bolls and seed-cotton. The bolls were well grown and evenly developed.

The lint was cream-coloured, fairly lustrous and soft, with some broken leaf and husk and some immature and stained fibre. The yield of lint from the seed-cotton on ginning was 34·2 per cent. and the yield per 100 seeds 6·9 grams.

The seeds were large and mostly covered with long greyish fuzz, but some seeds bore bright green fuzz and some smooth black seeds were also present.

The strength was uneven but good on the whole, and the length varied from 0·9 to 1·1 in.

The ginned cotton was valued at 8·75*d.* per lb.

This cotton was slightly stained, but otherwise of very satisfactory quality.

No. 2. "*Russell's Big Boll.*"—Grown at Yanco Experiment Farm. This was a sample of unginned cotton.

The lint was cream-coloured, lustrous, fairly soft and free from leaf and immature fibre. The sample gave a yield of 33·0 per cent. of lint on ginning, the yield per 100 seeds being 5·8 grams.

The seeds were large and mostly covered with long green fuzz, but in some cases with brown fuzz.

The cotton was of good strength and varied in length from 0·8 to 1·2 in.

The ginned cotton was valued at 8·50*d.* per lb.

This cotton was of very good quality, but a little less regular in length than sample No. 1.

No. 3. "*Russell's Big Boll.*"—Grown at Blacktown. This consisted of bolls which were well grown and evenly developed.

The lint was cream-coloured, fairly soft and lustrous, and practically free from immature fibre. The yield of lint from the seed-cotton on ginning was 36·5 per cent. and the yield per 100 seeds 7·5 grams.

The seeds were large and covered with long greyish-brown or green fuzz.

The strength of the cotton was irregular, but good on the whole. The length varied from 0·9 to 1·1 in.

The ginned cotton was valued at 9·00*d.* per lb.

This cotton was of even length and excellent appearance.

No. 4. "*Durango.*"—Grown at Yanco Experiment Farm. This was a sample of unginned cotton.

The lint was cream-coloured, soft, clean, lustrous and free from stains, but contained a little immature fibre. The yield of lint on ginning was 33·1 per cent. and the yield per 100 seeds 5·1 grams.

The seeds were large and mostly covered with long white fuzz, but in some cases with greenish fuzz.

This cotton was of irregular strength, some portions being of excellent strength and others rather weak. It varied in length from 0·8 to 1·2 in., but mostly from 1·1 to 1·2 in.

The ginned cotton was valued at 10·50*d.* per lb.

This cotton was a little longer than the preceding samples, and was therefore regarded as more valuable.

No. 5. "*Allen's Long Staple.*"—Grown at Narromine. This also consisted of unginned cotton.

The lint was cream-coloured, soft, clean and lustrous. The sample gave a yield of 27·6 per cent. of lint on ginning, the yield per 100 seeds being 3·1 grams.

The seeds were of medium size, and covered with long fuzz, in most cases white, but in a few cases green or grey in colour.

The strength of the cotton was mostly good, but partly soft and rather weak. The length varied from 0·8 to 1·2 in., but was mostly from 1·0 to 1·1 in.

The ginned cotton was valued at 9·50*d.* per lb.

The staple in this sample was shorter than is usual for Allen's Long Staple cotton, which generally has a length of about 1·5 in.

No. 6.—Grown at Pooncarie. The sample was described as "Allen's Long Staple," but was evidently not that variety. It was very mixed, and its identity is doubtful. It consisted of both ginned and unginned cotton.

The lint was fairly soft, with a brownish tint and rather dull appearance. The yield of lint on ginning was 32·4 per cent. and the yield per 100 seeds was 6·2 grams.

The seeds were large, smooth and black, with a small tuft of green fuzz at each end.

The strength of the cotton was somewhat uneven, but on the whole good. The length varied from 0·9 to 1·9 in., being mostly from 1·0 to 1·5 in.

The sample was too small and mixed for valuation.

This cotton somewhat resembled Egyptian Mitafifi, both in the colour and appearance of the lint and in the smooth, green-tufted seeds; but it was obviously of mixed staple.

No. 7.—Grown at Casino. This sample was described as "Allen's Long Staple," but the accuracy of this identification seems doubtful (see below). It consisted of bolls which were well grown and evenly developed.

The lint was lustrous, soft, clean, nearly white and free from immature fibre. The yield of lint from the seed-cotton on ginning was 34·4 per cent., the yield per 100 seeds being 7·2 grams.

The seeds were large and covered with long greyish-brown or green fuzz.

This cotton was of good strength and the length ranged from 0·8 to 1·2 in., being mostly from 1·0 to 1·1 in.

The sample was too small for valuation, but in general appearance and quality it closely resembled sample 2, and would probably realise about the same price.

The cotton appeared to resemble "Russell's Big Boll" rather than "Allen's Long Staple," both in the size and appearance of the seed and in the length of staple.

On the whole, these cottons from New South Wales were of good quality, and, if the yield per acre is satis-

factory, the cultivation appears very promising and should be encouraged. It may be mentioned that, at the present time, there is a scarcity of long-stapled cotton in the markets of the United Kingdom, and the value therefore rises rapidly as the length increases, cotton of a length of 1·2 to 1·3 in. being valued at 2*d.* or 3*d.* per lb. in advance of cotton of 1·0 in. For comparison with the valuations given above of these cottons from New South Wales, it may be mentioned that "good middling" American cotton was worth 8·00*d.* per lb. on the same date.

TOBACCO FROM NORTHERN PROVINCES, NIGERIA

Tobacco is grown for native use in almost every part of the Northern Provinces, Nigeria. The crop is carefully cultivated and manured, but the method of curing is very primitive and the product is quite unfit for export. In 1915 experiments were inaugurated by the Agricultural Department with the object of producing a "bright" tobacco of the Virginian type. Seed of well-known American varieties was obtained from the Department of Agriculture, Union of South Africa, and trials were started at Maigana and Ilorin Experiment Stations. The extreme dryness of the air at the former station made it difficult to handle the crop successfully, but at Ilorin the results were distinctly promising.

Four samples of tobacco produced in the experiments at Ilorin were received for examination in June 1916. According to information supplied by the Director of Agriculture, the soil on which the crop was raised consisted of a light sandy loam, rather deficient in plant food, having been cropped with maize and yams in successive years. A crop of cow-peas was grown on the land in the earlier part of the year, and was dug in as green manure one month before the tobacco seedlings were transplanted. The land was also manured with town refuse at the rate of approximately 2 tons per acre. On account of the dry season supervening the plants ripened somewhat prematurely, thus preventing the full development of the leaf.

The tobacco was cured partly by exposure to the sun and partly under cover; no artificial heat was used at any stage in the process.

The samples comprised three American tobaccos—viz. "Boyd," "Yellow Pryor" and "Sterling," and one native type. The characters of the leaves are shown in the following table:

	No. 1. Boyd.	No. 2. Native.	No. 3. Yellow Pryor.	No. 4. Sterling.
Size of leaves, length	15–25 in.	$10\frac{1}{2}$–17 in., mostly $16\frac{1}{2}$ in.	15–24 in.	$12\frac{1}{2}$–20 in.
,, ,, width	$5\frac{1}{2}$–13 in.	$2\frac{1}{2}$–6 in., mostly $4\frac{1}{2}$ in.	6–$14\frac{1}{2}$ in.	5–$11\frac{1}{2}$ in.
Colour	Pale to medium reddish-brown; a few leaves of a pale yellowish-brown tint.	Light brown to medium brown with a reddish to orange tint; a few leaves mottled yellow and dark brown.	Pale to medium reddish-brown; a few leaves mottled.	Uneven, varying from light to medium reddish-brown; a few leaves slightly mottled.
Texture	Of fair substance on the whole; a few leaves thin and weak.	Rather thin and in some cases weak.	Mostly of fair substance; some thin and rather weak.	Moderately thick and of fair substance.
Moisture in leaves, as received, *per cent.*	14·3	13·6	13·4	12·7

The samples on the whole were in good condition, but many of the leaves showed marks and a few torn leaves were present. All the tobaccos held fire well when burnt, but they gave off a rather pungent smoke.

The results of chemical examination expressed on the material conditioned to contain 12 per cent. of moisture are shown in the following table:

		No. 1. Boyd.	No. 2. Native.	No. 3. Yellow Pryor.	No. 4. Sterling.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture		12·0	12·0	12·0	12·0
Nicotine		4·2	3·9	4·1	4·4
Nitrogen		2·9	2·3	3·5	2·7
Ash		17·5	15·0	17·6	14·5
The ash contained:					
Lime	CaO	28·9	29·8	31·5	32·4
Magnesia	MgO	6·9	7·5	6·4	7·7
Potash	K_2O	17·4	17·9	17·1	17·7
Soda	Na_2O	2·1	1·9	1·9	1·4
Sulphates expressed as sulphuric acid	SO_3	1·3	1·1	1·5	1·4
Chlorides expressed as chlorine	Cl	0·9	2·4	1·7	1·0

The samples were submitted to a firm of tobacco merchants, who stated that if offered in good condition, *i.e.* containing from about 12 to 14 per cent. of moisture, all four tobaccos would be quite suitable for the English market. They valued the samples as follows:

"Boyd"	from 8*d.* to 9*d.* per lb.
"Native"	from 6*d.* to 6½*d.* per lb.
"Yellow Pryor" . . .	from 8*d.* to 9*d.* per lb.
"Sterling"	from 7*d.* to 7½*d.* per lb.

The firm pointed out that the above valuations represented the prices that would probably be realised in normal times, adding that under present conditions all grades of tobacco have been advanced in value from 25 to 50 per cent. owing to the prevailing scarcity on the market.

The results of analysis of these tobaccos show that they are rather too rich in nitrogen and nicotine, and to this is in part due the pungency of the smoke produced on burning. The excess of nitrogen and nicotine is no doubt due to the soil in which they were grown having been heavily manured recently with nitrogenous manures (see p. 32). The soil is, however, suitable for tobacco in other respects, judging from the results of analysis of the ash, which show that the latter is fairly rich in the desirable constituent potash and poor in the undesirable ingredients chlorides and sulphates.

In size of leaf the tobaccos are satisfactory, except in the case of No. 2, where the leaves are rather small and narrow for pipe tobacco. The best prices are paid for pipe tobacco of bright yellow colour. Such tobacco can probably only be obtained by the use of flue-curing barns, but it will be interesting to see whether it can be produced in the open under the rather unusual conditions obtaining in Nigeria.

Altogether these samples of tobacco are of promising quality, and it is satisfactory that in a first experiment of this kind, tobacco should be produced which would be readily saleable at what are good prices in the London market for this class of tobacco.

MANKETTI NUTS FROM SOUTH-WEST AFRICA

Manketti or munkuetti nuts are the product of a euphorbiaceous tree (*Ricinodendron Rautanenii*, Schinz). The tree, which grows to a height of 15–25 ft., is found in the South African veldt, and is especially plentiful in the region between Tsumeb and the Okawango River in the South-West Africa Protectorate. It forms extensive forests near the Omaramba River, about 50 miles from the rail-head at Tsumeb. The kernels of the nuts are oily and are eaten by the natives, whilst the husk surrounding the kernel is scraped off when dry and made into a kind of porridge. In 1911 a concession was granted for the collection of the nuts in the Omaramba River forests, and a trial consignment of 40 tons was sent to Europe, but the commercial exploitation of the nuts does not appear to have been proceeded with. The crop varies considerably from year to year, being dependent on the rainfall.

A sample of the nuts from South-West Africa was received for examination at the Imperial Institute in September 1916. It consisted of fruits from ¾ to 1 in. in diameter and from 1 to 1½ in. in length, composed of a thin, tough, reddish-brown husk (13 per cent.) and a soft, pulpy, pinkish-brown mesocarp (20 per cent.) covering the nut (67 per cent.). The nuts consisted of a thick, woody, brown shell (forming 50 per cent. of the entire fruit), a brittle, woody, greyish-brown seed-coat, and a rather soft, oily, friable, cream-coloured kernel. The kernel formed about 10 per cent. of the entire fruit.

The average weight of an entire fruit was 7·6 grams, of a nut 5·0 grams and of a kernel 0·7 gram.

The kernels as received contained 4·1 per cent. of moisture, and yielded 57·2 per cent. of a bright yellow liquid oil, equivalent to a yield of 59·6 per cent. from the dry kernels or 5·7 per cent. from the entire fruits as received.

The oil was submitted to examination with the following results:

	Present sample.	Figures previously recorded for manketti oil.	Linseed oil.	Soy-bean oil.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·9281	0·9286 to 0·9306	0·931 to 0·938	0·924 to 0·928
Acid value[1]	1·9	0·6 to 0·9	—	—
Saponification value[1]	191·5	193·0 to 195·2	186 to 195	190 to 193
Iodine value, *per cent.*	133·6	128·6 to 134·8	175 to 200	126 to 135

[1] *Milligrams of potash for 1 gram of oil.*

From the iodine value it is evident that this oil is a semi-drying oil, and is therefore not, as has been supposed, similar to castor oil. Further, the oil is insoluble in alcohol and readily soluble in light petroleum, whilst castor oil is soluble in alcohol and insoluble in light petroleum.

It is possible that the oil might be used for paint, varnish and soft soap manufacture; but it is not particularly suited for the first two purposes, and many cheap vegetable oils are already available for the manufacture of soft soap. The oil might perhaps be used for edible purposes if it were definitely found to have no injurious physiological effect. Physiological experiments with the oil were carried out a few years ago by German investigators, and are stated to have shown that the oil could be used as food.

A sample of the pulpy mesocarp of the fruit was submitted to examination as a possible cattle food. The material had a pleasant fruity smell and a slightly astringent but not unpleasant taste. It was analysed with the following results:

	Per cent.
Moisture	16·6
Crude proteins	7·9
Consisting of:	
True proteins	6·5
Other nitrogenous substances	1·4
Fat	1·6
Carbohydrates, etc. (by difference)	65·4
Fibre	3·0
Ash	5·5
Nutrient ratio[1]	1 : 8·6
Food units[2]	89

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

It will be seen from these figures that the pulp contains

only a moderate percentage of proteins. No true starch is present, but the carbohydrates are probably mostly digestible, as the percentage of fibre is low. The pulp should thus have a moderate nutrient value, but feeding trials would be necessary before it could be definitely recommended as a cattle food.

The results of the examination of the present sample are in close agreement with those previously recorded for "munkuetti" or "manketti" fruits, and show that the kernel oil might be useful commercially if the kernels could be remuneratively extracted. This, however, is very doubtful in view of the thickness of the shells and the very small proportion of kernel (only 10 per cent.) present in the fruit. The nut-cracking machines available at the Imperial Institute were tried but did not give satisfactory results, and it is clear that, owing to the extreme hardness of the shells and the softness of the kernels, great difficulty will be experienced in adapting any machine to crack the shells without damaging the kernels.

The shipment of the nuts to Europe for grinding and extraction of the oil by solvents would not be remunerative, as the yield of oil calculated on the entire nuts after removal of the pulpy mesocarp is low, viz. 8·5 per cent. It would therefore be necessary to extract the kernels in South Africa and ship them to Europe for the expression of the oil.

For dry kernels a value of about £20 per ton might be expected under present circumstances, and certainly not more than £12 to £14 per ton in normal times. This estimate is based on the assumption that the meal left after extraction of the oil from the kernels could be used for feeding purposes, which would require to be proved.

As stated above, the mesocarp pulp might be utilised locally for cattle feeding, if on trial it was found to have no injurious effect.

The problem presented by these fruits is very similar to that of utilising the fruits of *Balanites Maughamii* (see this BULLETIN, 1912, 10, 548). In both cases the valuable products, viz. the pulpy mesocarp and the soft kernel, form but a small proportion of the whole fruit, and the kernel is

protected by a shell which, with the nut-cracking machines available, is economically unbreakable. So long as other oil-seeds are obtainable, at reasonable rates, intractable nuts of this kind will remain unused.

SOME NEW OIL SEEDS

During the last few years a number of oil seeds derived from American palms have been received for examination at the Imperial Institute. The results of the examination of some of these have been published recently in the *Analyst* (1916, **41**, 298) by Messrs. G. T. Bray and F. L. Elliott, of the Scientific and Technical Research Department of the Imperial Institute. The oil seeds dealt with in the paper include babassu nuts (*Attalea* sp.), tucan or large Panama nuts (*Astrocaryum* sp.), Paraguay kernels (*Acrocomia* sp.), gru-gru kernels (*Acrocomia sclerocarpa*, Mart.), cohune nuts (*Attalea Cohune*, Mart.), and cokerite kernels (*Maximiliana regia*, Mart.). An account of the examination of the last three has already been given in this Bulletin (1913, **11**, 572; 1914, **12**, 237; 1916, **14**, 8), and detailed reference will be made here only to the others.

Babassu Kernels

These kernels, also known as Coco babassu and bassoba, are derived from a species of *Attalea*, possibly *A. funifera*, Mart. The tree is stated to be abundant in the State of Maranham, Brazil (*Dipl. and Cons. Reps., Ann. Ser.*, No. 5,526; *Report on the Trade of Para*, 1914 [Cd. 7620—136] 1915, p. 26), and considerable quantities of the kernels have been exported lately, the quantity in 1915 amounting to nearly 1,200 tons. The greater part of the kernels appears to have been obtained by hand-shelling, the nuts being placed on end in a hole in a board and struck with an axe; but British machinery for shelling the nuts is stated to have been introduced.

The kernels have been crushed on a fairly large scale in this country, and there seems to be every prospect of increased supplies being brought here. They are said to

have been sold at about £2 per ton less than the price paid for good copra.

The fruit is very similar in appearance to the Cohune palm fruit (see this BULLETIN, 1914, 12, 237), weighs on the average about 45 grams, and consists of an outer fibrous pericarp enclosing a hard-shelled nut containing several kernels. A single fruit examined at the Imperial Institute contained five kernels, but, from the size and formation of the kernels as exported from Brazil, it seems that this is an unusually large number.

The kernels are reddish-brown, and of a characteristic elongated shape pointed bluntly at the ends; they weigh on an average about 3 grams, and are 40–50 mm. long and about 13 mm. broad. They are easily distinguishable from Cohune kernels, which are shorter and rounder.

The kernels as received contained 4·2 per cent. of moisture and 67·2 per cent. (70·2 per cent. expressed on the dry kernels) of fairly hard, cream-coloured fat, resembling palm kernel and coconut oils in general appearance. In chemical character the fat is more closely allied to the former than the latter (cf. table below), and is similar, as would be expected, to Cohune kernel oil, although its iodine value is somewhat higher.

TABLE I

Chemical Characters of the Oils

	Babassu kernels.	Tucan kernels.	Paraguay kernels.	Palm kernels.	Coconut (copra).
Melting point	26° C.[1]	30·5° C.[1]	—	26–29° C.[2]	23–26° C.[2]
Solidifying point of fatty acids	23° C.	27° C.	21° C.	20·0–25·5° C.	21·2–25·2° C.
Specific gravity at $\frac{100° C.}{15° C.}$	0·868	0·867	0·865	0·873	0·874
Acid value[3]	5·5	2·9	26·1	—	—
Saponification value[3]	249	249	247	245–248	260–262
Iodine value, *per cent.* (Hübl, 17 hrs.)	15·6	11·6	28·5	14–17·5	7–9
Unsaponifiable matter, *per cent.*	0·3	0·3	0·3	—	—
Volatile acids, soluble[4]	5·8	3·8	6·5	5·0–7·6	6·65–8·0
,, ,, insoluble[4]	10·2	5·9	10·2	10–12	15–20

[1] *Open tube method.* [2] *Capillary tube method—complete fusion.*
[3] *Milligrams of potash for* 1 *gram of oil.*
[4] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of oil.*

TABLE II

Composition of Residual Meals

	Babassu kernel meal.[1]	Tucan kernel meal.[1]	Paraguay kernel meal.[1]	English-made palm kernel cake.		English-made coconut cake.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8·5	8·4	8·7	9·6	10·7	11·9
Crude proteins	23·2	10·0	31·6	17·8	17·1	21·8
Consisting of:						
True proteins	22·0	10·0	31·4	—	—	—
Other nitrogenous substances	1·2	nil	0·2	—	—	—
Fat	7·0	7·0	7·0	8·2	8·2	8·4
Carbohydrates	45·9	62·9	35·5	50·6	51·1	42·6
Fibre	10·6	9·5	11·7	10·1	9·5	9·4
Ash	4·8	2·2	5·5	3·9	3·4	5·9
Nutrient ratio[2]	1 : 2·7	1 : 7·9	1 : 1·6	1 : 3·9	1 : 4·1	1 : 2·8
Food units[3]	121·4	105·4	132·0	116	114	118

[1] *Calculated to contain 7 per cent. of fat.*

[2] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[3] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The results of examination of the residual meal show that it should possess a feeding value about equal to that of coconut cake and somewhat superior to that of palm kernel cake, but so far as is known no results of feeding trials have yet been published.

Tucan or Large Panama Nuts

"Tucan" or "tucum" nuts are probably derived from *Astrocaryum vulgare*, Mart., and specimens received under the name "large Panama" nuts appear to be identical.

The tucan kernels weighed on an average 3·6 grams and measured 18–25 mm. in length and 13–18 mm. in diameter; the outer skin was smooth and brown, and the white flesh harder and tougher than that of palm kernels or copra; in fact, the kernels were so hard that extraction of the oil was slow and difficult, and it seems quite possible that the kernels may prove troublesome to work on account of their hardness.

The tucan kernels contained 6·5 per cent. of moisture and yielded 48·6 per cent. of fat (52·0 per cent. expressed on the dried material); the kernels of the large Panama nuts

contained 7·1 per cent. of moisture and yielded 37·6 per cent. of fat (40·5 per cent. expressed on the dried material). The fat extracted from the former was cream-coloured and fairly hard; in chemical character it resembled palm-kernel oil, but contained a smaller amount of soluble volatile acids and had a somewhat higher melting point. The residual meal contained only 10 per cent. of proteins, and is obviously inferior to coconut or palm-kernel meal. Although the meal yields only about 10 per-cent. of "crude" fibre, the tough nature of the kernels seems likely to render the residual meal somewhat indigestible.

The kernels are stated to have been sold at from £1 to £2 per ton below the price of fine palm kernels.

Paraguay Kernels

These appear to be derived from a species of *Acrocomia*, and are probably the source of "Mocaya" or "Mbocaya" oil, which, according to Lewkowitsch (*Chemistry and Technology of Oils, Fats and Waxes*, 1914, vol. ii, p. 607), is derived from the kernels of *A. sclerocarpa* in Paraguay. The kernels examined at the Imperial Institute are smaller than, but otherwise indistinguishable in appearance from, gru-gru kernels (*A. sclerocarpa*) from the West Indies; the former, however, contain a somewhat higher percentage of fat of decidedly softer consistency and higher iodine value. In view of the fact that comparatively little is known of South American palms and of the difficulty of identifying the species from the seed or fruit alone, it is quite probable that gru-gru and Paraguay kernels are not identical in origin.

The Paraguay kernels are roughly spherical, about 12 mm. in diameter, and weigh about 1 gram each; the skin is almost black and the flesh softer than that of the West African oil-palm kernels. The kernels as received contained 6·0 per cent. of moisture and 65·2 per cent. of fat (69·4 per cent. expressed on the dried material). The fat is decidedly softer than either coconut or palm-kernel oils, being only semi-solid at ordinary temperature; the iodine value is higher than that of either of these oils or of the oils derived from the other kinds of palm kernels examined.

The residual meal of Paraguay kernels is richer in proteins than coconut cake and should have a high feeding value. The kernels are stated to have been sold recently in Liverpool at prices between those of fine palm kernels and copra.

General Conclusions

The kernels of the various palms mentioned above are, with the exception of those of the tucan or large Panama nuts, as rich in fat or even richer than those of the West African oil palm. They seem destined, therefore, to form valuable additions to the oil seeds now utilised as sources of fat in the edible fat industry. The tucan and Paraguay nuts do not offer any particular difficulty in the way of exploitation, as the shells can be cracked by machinery such as is already used for ordinary palm nuts in West Africa (see p. 73). In the case of babassu nuts, however, like Cohune nuts, the problem of extracting the kernels is a difficult one. The fruits have a fibrous pericarp, the removal of which is generally regarded as necessary before the nuts can be cracked; further, the nut-shell is thick and hard, and the usual presence of several kernels also tends to render cracking difficult. Several machines have been designed both for removing the fibrous pericarp and for cracking the nuts (see p. 75), but comparatively little is known about their efficiency.

BURMESE BLACK VARNISH OR LACQUER.—II

In a previous number of this Bulletin (1910, 8, 273) an account was given of the preparation and characteristics of Burmese black varnish or lacquer or, to give it its native name, "thitsi," together with a description of the manufacture of Burmese lacquer-ware. During the last few years an attempt has been made by the Imperial Institute at the request of the Forest Department in India to induce users of varnishes in this country and on the Continent to experiment with this material with a view to its utilisation in European industries. In the present article it is proposed to give an account of the results of these enquiries, but as will be seen later the prospects of marketing the

material in any quantity in this country or on the Continent are not very hopeful, though further trials with it are still in progress.

The Burmese lacquer is essentially a natural varnish obtained from the "black varnish tree" (*Melanorrhoea usitata*, Wallich, Nat. Ord. Anacardiaceæ), a deciduous species 50–60 ft. high, which occurs in various parts of Burma, in the native state of Manipur, lying between Burma and Assam, and in Siam. The material is obtained by making V-shaped incisions in the bark and collecting the exuding liquid varnish in bamboo cups. It is in all respects similar to Chinese lacquer, the natural varnish used in the preparation of the famous lacquer-wares of China and Japan. "Thitsi" is used in Burma in a liquid state as a varnish for wood-work and for waterproofing paper or cloth. Coloured with various pigments it is employed to decorate articles of domestic or religious use, and mixed with ashes or teak sawdust it is used as a kind of putty which is applied to wood-work or basket-ware to form a foundation on which finishing coats of the varnish are afterwards laid. It is also used as a cement, particularly in the manufacture of the glass mosaics used in the decoration of Buddhist temples. Specimens of "thitsi" lacquer and of various styles of Burmese lacquer-ware and glass mosaics may be seen in the Indian Section of the Public Exhibition Galleries of the Imperial Institute.

The quantity and value of the "thitsi" extracted in recent years from the forests in the different Forest Circles in Burma are shown in the following table:

Forest Circle.	1912–13.		1913–14.		1914–15.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Pegu	17	3½	15	3	3	½
Tenasserim	1,024	140½	866	96	364	102½
Northern	1,114	231	715	148	2,408	499
Southern	1,508	314	3,122	651	2,615	536
Total	3,663	689	4,718	898	5,390	1,138

In 1911 a supply of "thitsi" was sent to the Imperial Institute by the Imperial Forest Economist. Three grades

were supplied, which were stated to differ only in the amount of water present, and this statement was borne out by the results of a preliminary examination of the material at the Imperial Institute, as is shown in the following table:

	Grade I. Per cent.	Grade II. Per cent.	Grade III. Per cent.
Water	5·3	33·5	64·0
Ash	0·2	0·1	0·1
Matter insoluble in benzene	2·6	1·8	1·6

The residues obtained on drying the three grades were similar in appearance and general properties.

Trials conducted at the Imperial Institute showed that the varnish required about three days to harden in an atmosphere saturated with moisture at a temperature of 30–35° C., and that in dry air at ordinary temperatures it remained sticky for a number of days.

Samples of "thitsi" were sent for trial to technical chemists specially interested in varnishes, manufacturers of paints and varnishes, both in this country and on the Continent, and also to firms who specialised in lacquer-ware manufacture. The following are typical of the reports obtained:

(1) A large firm of cabinet makers reported that so far as their experiments had gone they found "thitsi" to be quite as serviceable as the Chinese lacquer which they have been using, except that it takes somewhat longer to dry. They stated that there is no reason why they should not use "thitsi" in place of Chinese lacquer, and they asked for information as to where supplies could be obtained. The firm were therefore put into communication with merchants in Rangoon, and they were also supplied with particulars of prices and quantities available.

(2) A firm of varnish manufacturers stated that they did not consider there would be any advantage in using "thitsi" in the United Kingdom, either on wood or metal, as there are many methods of obtaining better results with materials which dry more quickly and at ordinary temperatures.

(3) Another firm reported that if the material dried quickly under ordinary conditions it might be of great use for their purposes, but that after experimenting with the

varnish they had to conclude that it would be impracticable to employ it, owing to the special conditions necessary for drying.

(4) A third firm of manufacturers also reported that the results of their trials with the "thitsi" were unfavourable, and they doubted whether the material would be of any value in their trade.

(5) A firm interested in varnish-making materials reported that varnish made with Grade I of the "thitsi" was very resistant to chemical and physical influences, particularly to acids. They stated, however, that as the varnish can only be got to dry in a very damp atmosphere, its use would always necessitate special treatment. They added that the varnish possesses great elasticity, and could be used for small wooden articles and for leather goods.

This firm subsequently reported that, as the result of their experiments, they hoped to be able to utilise the material. Just previous to the outbreak of war they were put into touch with suppliers in Burma, with a view to obtaining a trial consignment of the product for further experiments, including the devising, if possible, of suitable methods of using "thitsi" unmixed with other substances, but, as the experiments were to be conducted on the Continent, no further report has been received.

(6) Another firm reported that they considered the material to be much like Japanese varnish, derived from *Rhus vernicifera*, but devoid of the acrid and irritant properties of the latter. They, like the last-mentioned firm, found that a coat of "thitsi" was extremely resistant to strong alkalis and acids, and that even when exposed for a time to the action of water it remained practically unaffected. They confirmed the view that for the drying of "thitsi" the conditions required are similar to those required for the Japanese varnish, *i.e.* it must be left in a cool damp place and not in dry air or exposed to the light.

(7) Two technical chemists to whom samples were submitted were of opinion that it would not be possible to find a market for the lacquer, owing to the special conditions which are necessary in order to get good results.

The results of these enquiries show that it may be

possible to find a small market in Europe for "thitsi," but that there is at present no prospect of an extensive use being found for it.

Some years ago an attempt was made by a German firm to popularise Chinese lacquer in Europe, but this attempt also seems to have failed, and so far as could be ascertained by careful enquiries before the outbreak of war there was not a large demand in Germany for Chinese lacquer or for certain special preparations made from it and which were at one time extensively advertised in German technical journals. It is probable that the best policy in connection with the utilisation of "thitsi" will be to encourage its use in Burma for the production of lacquer-ware for export, as there is little doubt that a large market could be found in this country for some of the better-class small lacquer-wares produced in Burma. A good deal is now being done in India to encourage the revival of artistic crafts, and it is interesting to note that Burmese lacquer-ware is one of those receiving attention.

SPECIAL ARTICLE

THE IMPERIAL INSTITUTE

Debate in the House of Lords

The following is a summary of the debate which took place in the House of Lords on December 20, 1916, on a motion by Lord Sudeley calling attention to the position of the Imperial Institute and proposing to resolve: "That His Majesty's Government should forthwith take the necessary steps to secure that adequate funds are provided for carrying out to the fullest extent the operations of the Imperial Institute."

Lord Sudeley said that the operations of the Institute during the war in helping to fill up the many gaps in trade by making use of the natural resources of the Empire had been very large, but much work had to remain undone for want of necessary funds. The total income was only £17,000, and great credit was due to the staff that so much had been accomplished and so far without any

additional funds to cope with the increased work. The additional sum likely to be required would probably be not much more than £40,000 a year. The unique service which the Imperial Institute renders to the commercial community was now acknowledged throughout the country. Arrangements had been made with the Board of Trade that the Imperial Institute should act as the centre for information in this country respecting the sources of the raw materials of the Empire and their utilisation in Imperial commerce. Under the new Institute Management Act there was a Council of twenty-five, composed of representatives of the Dominions and India and of some of the most able and competent men in the commercial community. These men had been in office for some months, and yet he understood that no further means had been given them to carry out the important work for which they had accepted office.

LORD RATHCREEDAN seconded the motion. Giving examples of the work of the Imperial Institute in promoting the effective use of the raw materials of the Empire in connection with the war, he said that the Institute had been the means of offering alternate sources of supply in the shape of necessary minerals for the manufacture of munitions. As regards medical comforts for the British sick and wounded, it had shown that opium obtained from India was as good as the best Turkish or Persian opium. It had shown that thymol could be obtained from an Indian seed, that atropine could be obtained from Egyptian henbane, that the podophyllum produced in India was as good as the podophyllum formerly got from America. When great difficulties were being experienced with regard to synthetic dyes for khaki cloth it furnished information with reference to a source of supply of the natural dyestuff, fustic, in Jamaica, and also, which was of great importance, it had been the means of promoting the use of new animal feeding-stuffs for the country. Those who had considerable knowledge of agriculture knew that the prices of certain products, for example all dairy products, poultry, eggs, bacon, and meat generally, rose more or less in sympathy with the price of feeding-stuffs; and the Imperial Institute had been the means of showing that within the Empire

there were immense resources of nuts, beans and seeds that helped to make excellent cake and feeding-stuffs for stock. If furnished with adequate funds the Imperial Institute could be one of the industrial and commercial pivots of the Empire so far as information respecting raw materials is concerned. It should be the centre to which manufacturers and merchants could apply for any information they wanted as regards the resources of the Empire. In order to disseminate the information, it would be necessary to do more and in addition to publications to have popular lectures and exhibitions at the great centres of population throughout the country. Without funds all this was impossible. For example, the Institute had a mass of information and had technically examined numbers of products that would be of value to almost all trades, with reference to minerals, rubber, timber, leather, paper and the textile trades; and these should be displayed, in such a centre as Manchester, to the merchants and manufacturers so that they could see not only how they could use such products, but what was the supply, because the Imperial Institute was the centre at which information with reference to sources of raw supply, uses, and the means of distribution were brought together. If money could be provided to strengthen the staff, and in addition the present space belonging to the Imperial Institute which had been temporarily loaned to the University of London could be placed immediately at its disposal, he thought the Institute would have the opportunities it deserved.

VISCOUNT HALDANE, after briefly reviewing the history of the Imperial Institute, said that the work consisted not only of research, but of another piece of work, which is valuable. The Institute contained a sort of register, accompanied by an exhibition of Colonial and Indian products—a very useful and valuable thing—and if it were necessary to expend money to make the classification and exhibition work more effective by all means let that be done. There was also a research department where valuable work has been done, but he suggested to the Government that before giving an affirmative answer to the appeal which had been addressed to them they should take into account the

necessity of submitting the question of the form in which any assistance for research should be given, and under what conditions it should be given, to the Research Committee of the Privy Council. Not only had the Research Committee the machinery for investigating the question, but there had now been set up a Department of the State for administering funds to be applied for research. He submitted that if money was to be granted for scientific research in the Imperial Institute, action ought to be taken through the body which had been set up for the purpose, and which alone could survey the research work, which had to be done as a whole. The new Executive Council of the Institute was not an expert body for this purpose.

LORD ISLINGTON (Under-Secretary of State for India) in reply pointed out that the Institute was well qualified to undertake on an increased scale its existing work, including the work conducted in its laboratories, of which some of the results had been referred to, but this work was not in the main scientific research as Lord Haldane supposed. The Institute was now well provided not only with a Council representative of the whole Empire, but also with Advisory Committees including distinguished experts in all subjects, and these assisted the Council in respect of the current work of the Institute. He interpreted the speeches which had been made that afternoon as an encouraging indication of the interest displayed in the work of the Imperial Institute. In the course of the debates which took place when the Bill, which as an Act now governed the Imperial Institute, was passing through the House of Lords he undertook that steps should be taken to bring about as far as possible a close association between representatives of the Dominions and the Colonies and of India with the Imperial Institute. All the leading representatives of various parts of the Empire who had visited the United Kingdom in the past few months had been invited to inspect the work of the Institute. The Prime Minister of New Zealand, Mr. Massey, has been able to do this. He has expressed considerable interest in the work of the Institute, and hopes that the extension of its usefulness to New Zealand would come under his

Government's careful and sympathetic consideration when he returned to New Zealand. The Executive Council of the Institute also had the advantage at one of its meetings of the presence of Sir Joseph Ward, ex-Prime Minister and the present Minister for Finance of New Zealand. The Governments of the Dominions, the Colonies, the Protectorates and the Government of India had been officially notified in this connection that any of their chief officials or technical officers who were visiting the United Kingdom would have a very ready welcome at the Institute, and that, if it was deemed useful and desirable, their presence would be invited at meetings of one or other of the technical committees attached to the Institute.

The Executive Council, which was the representative and administrative body set up recently by the Imperial Institute (Management) Act, met quarterly, and from the Executive Council there had been appointed a Finance and General Purposes Committee, which met monthly, and upon which devolved the main consideration of the varied operations of the Institute. He had been appointed Chairman of the Finance and General Purposes Committee, and, therefore, he had the advantage in recent months of acquiring a close insight into the workings of the Institute. Committees had also been appointed to consider the needs and interests of the chief countries of the Empire. Each Dominion formed its own Committee under its High Commissioner in London. The Union of South Africa and the Dominion of New Zealand had appointed their Committees, and he hoped that before long the other Dominions would do likewise. A large and representative Committee had been appointed for India, and had recently been charged by the Secretary of State for India to enquire into the promotion of Imperial trade in regard to Indian raw materials. From that main Committee there had been appointed subcommittees to consider the prospects of increased trade in such products as hides, tanning materials, cereals, oil seeds, gums, resins, fibres and timbers. The ground-work of the enquiry was found in the information of a technical character respecting Indian raw materials which the Imperial Institute had accumulated during the past twenty years.

A very full account of that work had been given by the Director of the Institute, Prof. Dunstan, in a recent paper read before the Royal Society of Arts. One of the most important aspects of the enquiry was to find Imperial outlets for Indian products which formerly had gone on a very large scale to Germany. For example, the raw hides which India produced in very large quantity, and from which excellent leather was manufactured, used to go largely to Germany, the whole organisation of that particular trade having been in German hands. The Committee who were considering the matter were preparing a scheme which he hoped might result in Indian hides being made into leather in the United Kingdom and in the Dominions to a very much larger extent than had formerly been the case. The Indian Committee, as a whole, in seeking the employment of raw material in the Empire, might be regarded as complementary to the Commission that was sitting in India to investigate and report on the extension of industries in that country. He hoped that, in addition to the Committees for the Dominions and India, there would be formed by degrees similar Committees of the Imperial Institute for other parts of the Empire.

Besides the Committees for the different countries, there were several advisory technical Committees appointed by the Council. These Committees worked in close touch with the Technical Information Bureau and the Scientific and Technical Department of the Institute. There was a Committee on Raw Materials, constituted of members drawn from the various Chambers of Commerce in the country, with Sir Algernon Firth as Chairman. Special Committees were at work on timbers, silk, rubber, minerals, and tanning materials. In addition to industrial and commercial representatives, the Institute enjoyed the co-operation of men of science distinguished for their knowledge of special aspects of the subjects of enquiry, including at the present time no fewer than six Fellows of the Royal Society. He wished to emphasise the point that, while the Imperial Institute made use of all the scientific knowledge that could be obtained, the commercial result was the most prominent in the activities of the Institute. It was for the

commercial community to say what it needed, and it was the business of the Institute to provide for that need, as far as the means at its disposal allowed. The Institute aimed at being what he might term a clearing-house for information on raw materials within the Empire and their utilisation. The work was carried out in three main branches. First, there was the Technical Information Bureau, the business of which was the collection and dissemination of information. Secondly, there was the Scientific and Technical Department, whose comprehensive organisation included laboratories for the necessary experimental work. Thirdly, there were the Public Exhibition Galleries and sample rooms. The work of all these departments was directed to one end—the utilisation of the raw materials of the Empire within the Empire.

The war had shown the extent to which the British people had depended on Germany and on foreign countries generally for articles of prime necessity in the conduct of the war and in the supply of ordinary national needs. In remedying that state of affairs the Institute might be said to have played a useful and by no means unimportant part. He could enumerate a list of Empire raw materials, hitherto either unemployed or employed by foreign and enemy countries that had now, after trials and investigation by the Institute, been brought into commercial use in the United Kingdom. The further employment in trade and industry of such materials could only be realised with effectiveness and permanence by employing as a medium in the first stage of the problem an institution planned, equipped and staffed for initiating commercial enterprise, as the Imperial Institute was. He did not suggest that the Institute alone could or should provide all the scientific and technical help required by British industries which had reached a high stage of specialisation; but if successful results were to be secured in the first stage, where the problem was to find the appropriate material for the particular purpose, neither on the one hand would the employment of a mere trade enquiry agency, unfurnished with scientific and technical knowledge, be effective, nor on the other hand would scientific research alone, however pro-

found, be successful, unless it had intimately associated with it that practical commercial knowledge which could provide the manufacturer with the precise information he required. The aim of the Institute was to present to the enquirer not a scientific treatise, but a practical report, embodying the careful co-ordination of the results of scientific, technical and commercial investigation, so constructed and composed as to be of real and immediate service in initiating commercial enterprise. It was evident that, to fulfil such objects successfully, an institution must be equipped with experienced officers possessing the essential blend of scientific, technical and commercial knowledge, so that the manufacturer, from wherever he might come within the Empire, might apply with success for the particular kind of raw material which he desired for his manufactory.

In dealing with so large a subject as the raw materials of the Empire the Institute had found it very necessary that its various activities should be co-ordinated and adjusted to those of other departments carrying on work of a similar character. Co-operation had been arranged with the Board of Trade, which was carrying on an active commercial crusade also. Generally speaking it had been agreed that the Imperial Institute should deal with all questions relating to the raw materials of the Empire, the sources of their supply, and their commercial utilisation. The Institute hoped also to work in close co-operation with the newly established Committee of the Privy Council for Scientific and Industrial Research, so far as any fundamental research was concerned. Much was expected from that important Committee. It was advised by a Council of scientific men, one of whom had a seat on the Executive Council of the Institute, whilst the Director of the Institute was an assessor to the Council for Research. In regard to the observations that fell from Lord Haldane, the main work of the Imperial Institute, as had already been explained, was commercial, and the Council has appointed a number of technical Committees to advise it in respect of this work, including scientific experts. In the course of that commercial work numerous

scientific problems emerged, the pursuit of which might conceivably lead to results of commercial and industrial value. In former years some of the more extended scientific investigation had been pursued in the laboratories of the Imperial Institute by members of the staff with high scientific qualifications, but with the increase in the volume of work connected with the commercial aspects of raw materials this was no longer possible in all cases. There would still be occasions, he hoped, when more extended research might be undertaken by qualified officers of the Institute, and if need be in co-operation with the Council for Scientific and Industrial Research, to whom in such cases the Council of the Institute would go in the hopeful anticipation that they would provide the additional funds to carry out such work.

Giving some illustrations of the practical value of the work done by the Imperial Institute, Lord Islington said it was due to the Institute that West Africa was now supplied with coal of its own. A Mineral Survey of Nigeria was conducted some time ago in connection with the Institute, and among other important results was the discovery of a large coal supply, the commercial value of which was determined in the Institute's laboratories. A similar Survey in Ceylon, under the auspices of the Imperial Institute, led to the discovery of certain rare earths of great value in the gas-mantle industry, which had been completely under the domination of Germany. Again, in Nyasaland mica had been discovered, in addition to coal, and had been commercially worked. Then, since the commencement of the war, there had been a dearth of material essential for the manufacture of certain explosives. That material used to be provided by Germany. Information at the Imperial Institute showed that it existed in several countries within the Empire. A specimen from one country proved, after tests in the Institute and trials by the manufacturers, to be suitable, and several tons had been shipped to the United Kingdom. The Institute, therefore, was not merely a centre for information, but a business organisation of singular effectiveness. It was doing an important part of that spade work which was so essential if the present almost universal

demand throughout the country was to be realised that the British Empire should make the very fullest use of its own natural wealth, and should become as far as possible a self-contained Empire. There was one other example which he would like to give of the practical work done by the Institute. In the early stages of the war the United Kingdom experienced a great scarcity of boxwood, which was formerly obtained from Turkey. It was employed in several industries and was essential for wood engraving. The Imperial Institute knew that boxwood with similar properties occurred in South Africa. Samples were obtained and tested by the Institute with satisfactory results and introduced to the trade, and this wood was now being used by manufacturers for the same purposes as the wood which formerly came from Turkey. He had given instances to emphasise the point that, for real assistance to industry, success depended on having in the same institution, for this particular type of commercial work, knowledge of the source of supply, scientific and technical knowledge of the material, and that amount of commercial knowledge which would effectively bring the producer into commercial contact with the manufacturer. With very limited resources and now a reduced staff, the Institute had proved not merely its utility, but, he ventured to say, its necessity as an integral part in any scheme of Imperial development. In discussing the affairs of the Institute he wished to pay a tribute, as had already been done by a former speaker, to its staff, and he knew that in paying that tribute he was expressing the views of every member of the Executive Council. The staff had displayed the most unremitting attention and industry to the increased work which had been imposed upon them; they had laboured with the greatest possible ability and loyalty; and he might add that they had throughout performed their work without asking for any additional remuneration.

Referring, in conclusion, to the Resolution that adequate funds be provided to carry out to the fullest extent the operations of the Imperial Institute, Lord Islington said that so far he had been speaking as the Chairman of the Executive Council of the Imperial Institute; but, when it

came to the question of ways and means, he had to speak on behalf of the Government and of the Department which controlled the Institute. The expenditure on the Institute during the past year had been approximately £18,000; the income, owing to reductions chiefly from war economies in certain contributions from outside, came approximately to £17,000—namely, £8,000 from grants from the Dominions, Colonies and Protectorates, and the Government of India; £4,000 from invested funds; £2,000 from miscellaneous receipts; and £2,500 grant from the Treasury. The deficit of the past had been made up from a small deposit balance that the Institute had at its disposal. No official application had yet been made to the Government for an increased grant. They were purposely waiting for the appropriate occasion when the Estimates would be submitted for the year. In view of the Resolution, however, he had communicated with the Secretary of State for the Colonies, through whom all applications for grants, whether from countries overseas or from the Treasury, were made, and Mr. Walter Long had authorised him to say on his behalf that he was fully alive to the importance of the Institute receiving adequate financial assistance from all parts of the Empire, and that he would give the most careful consideration to any suggestions which the Council of the Institute might put before him. He (Lord Islington) was hopeful that Mr. Long's assistance might be secured to obtain larger grants from some of the Colonies and Protectorates, which were deriving direct benefit from the Institute. Likewise he hoped that the Dominion Governments, through the Committees presided over by their High Commissioners, would be induced to increase their grants, and that the Government of India might see its way to afford a larger contribution. Lastly, he was hopeful that the Treasury would assist to a substantial extent beyond the present modest grant of £2,500. In reply to Lord Haldane, he made a clear distinction between the grant that might be made by the Treasury and grants for special scientific research that might be asked for from the Committee for Scientific and Industrial Research. He hoped—speaking again as Chairman of the Council of the Institute—that

all the commercial work of the Institute would be supported directly and generously by the Treasury, because it was to be distinguished from fundamental or specialised scientific research, with which there would be no overlapping so far as the work of the Institute is concerned.

It should be borne in mind that the Imperial Institute was a public institution, which filled a place as a centre and clearing-house which was not filled by any other Institution in the Empire, that for some years it has been in active operation on recognised lines, and that it is under the management of a Council representative of the Empire and of the whole commercial and official world in this country which is assisted by scientific and commercial experts. Lastly, it is under the control of a Government Department. He thought that these facts constituted a very solid claim for assistance from the Treasury in accordance with the requirements of the Institute. But he would put the claim even further than that. If the widespread demand throughout the Empire for vigorous and immediate action to develop inter-Imperial commerce by the utilisation of Imperial raw materials had any meaning and any force in it, and if it could be shown, as he had endeavoured to show, that the Imperial Institute was contributing a large, valuable, and he would add indispensable share towards that end, then he could not help feeling that all would agree that the case for real and adequate assistance of a financial character to the Institute had become unanswerable.

Lord Sudeley expressed his satisfaction with the statement made by Lord Islington, and the motion was, by leave, withdrawn.

GENERAL ARTICLES

THE AFRICAN PALM OIL INDUSTRY.— III. MACHINERY

In previous articles in this Bulletin (1909, 7, 357; 1913, 11, 206) an account was given of the distribution of the oil palm (*Elaeis guineensis*, Jacq.), its varieties, the methods of preparing the oil and kernels and various other points

of interest in connection with this important industry, including the results of investigation at the Imperial Institute of the fruits and oil of numerous varieties of oil palm occurring in British West Africa, Nyasaland, Uganda and elsewhere.

In view of the great importance of the industry and of the fact that much attention has been given in recent years to the mechanical extraction of palm oil, it is now considered advisable to place on record further information available relating to special machinery for use in the extraction of palm oil and palm kernels from oil-palm fruits.

At one time the whole of the enormous quantity of palm oil and palm kernels produced in West Africa was prepared by crude native methods (see this BULLETIN, 1909, 7, 384) and this is still true of the bulk of the oil and kernels. The inefficiency of these methods has long been recognised, and is evident from the fact that the native processes do not succeed in obtaining more than about 12 per cent. of palm oil from fruit containing from 17 to 20 per cent. of oil. Further, the tedious native method of cracking palm nuts by hand necessitates so large an amount of labour that in many districts large quantities of nuts are allowed to go to waste.

The first power-driven machinery for cracking palm nuts is believed to have been introduced into West Africa in 1877 by Mr. C. A. Moore of Liverpool, and was devised by Messrs. Mather and Platt, Ltd., of Salford. Hand machines were introduced about 15 or 20 years later.

In 1901 a prize offered by the Kolonial Wirtschaftlichen Kommittee of the German Kolonialgesellschaft (*Verhand. Kol. Wirt. Kom.*, 1909, No. 1, p. 54) was awarded for a complete set of small machines constructed by the firm of F. Haake in Berlin and designed to extract palm oil from the fruits and also to crack the nuts and liberate the kernels. Plant made by this firm was exhibited in 1909 in Berlin and afterwards erected at Mamfe on the Cross River (Cameroons). Similar plant was also erected at Viktoria in the Cameroons, and at about the same time a French firm erected a plant of French make at Cotonou in Dahomey (see p. 67). These early factories were all on a small and

almost experimental scale, generally working about 5 tons of palm fruit per day.

Numerous factories have since then been installed in West Africa, and plants designed by other firms, including several machines of British design and construction, are now in operation. Much of this machinery is of special design and has been constructed to the order of large syndicates, and in such cases full details of the machinery and methods employed are naturally not available.

Important Factors in the Mechanical Preparation of Palm Oil

Reference to the first article on the African oil palm which appeared in this Bulletin (1909, 7, 357) will show that the oil palm is, when mature, a tree of considerable size, bearing its fruit at the summit of a branchless trunk necessitating the climbing of the tree by a skilled native to obtain the fruit. The number and weight of the fruit bunches, often termed "heads" or "hands," vary according to conditions of soil and climate and probably also with the variety of the tree. As the bulk of the produce is obtained from wild or semi-wild trees it is difficult to estimate the yield of fruit from a given area, and the earlier estimates are widely divergent. Trustworthy data on this point are obviously important where a regular supply of fruit is essential, as in the case of an oil factory.

The question of yield per acre is further complicated by the existence of several varieties of oil palm differing widely in the yield of oil and in the ease with which their nuts may be shelled (cf. this Bulletin, 1909, 7, 362; 1913, 11, 218); some of these varieties would be obviously superior as sources of oil and kernels, but it is uncertain even now whether they can be cultivated "true to seed" or whether they bear as heavy crops as the ordinary varieties. Experiments are being made in various parts of West Africa with the different varieties, but no conclusive results have hitherto been published, although such results will probably be available shortly (cf. this Bulletin, 1916, 14, 125). This point is of importance, because although there are enormous tracts of wild oil palms available, it seems

highly probable that factories requiring large supplies of palm fruit near at hand will have to resort to plantation methods, in which case the choice of the best variety of palm for planting will be essential.

In many areas much labour must be expended in thinning out the trees and opening up paths. Although no details appear to exist of any attempts to cultivate the oil palm on a large scale in West Africa, a good deal of information relating to the yields obtainable from palm trees in different localities has been amassed in recent years, and more reliable estimates of expected yields can now be arrived at. According to Adam (*Le Palmier à huile*, pp. 118–121), an average yield of about 10 fruit heads, each weighing 13·2 lb. and equivalent to 85 lb. of fruit per tree per annum, may be counted on in districts favourable to the oil palm, such as Lower Dahomey. Farquhar (*The Oil Palm and its Varieties*, p. 20) says that an average of five bunches is obtainable in favourable districts in Nigeria, each bunch weighing 31 lb., but that the bunches are smaller in the dry zone and in dense forest. There is no doubt that the yields of fruit vary considerably in different localities, and the selection of a site for an oil-palm factory necessitates therefore a careful examination of the productivity of oil palms in the vicinity.

Some idea of the minimum number of trees which would be needed to supply a factory requiring 5 tons of palm fruit per day, and therefore producing from about ¾ to 1 ton of palm oil, can be arrived at, and will serve to show the considerable labour and large area required to keep even such a small factory adequately supplied. As the fruit heads consist of only about 64 per cent. of fruit, the remainder being useless fibrous stem, bracts, etc., it would be necessary to collect and transport to the factory nearly 8 tons of fruit heads daily, or, taking the number of working days in the year as 200 and thus allowing for the fact that the palms do not bear fully throughout the year, over 1,500 tons per annum. Assuming a yield of 85 lb. of fruit per tree per annum (Adam, *see* above), at least 26,000 trees would be required to produce the 1,000 tons of fruit worked annually. A similar estimate is given by

Bücher (*Koloniale Rundschau*, 1910, p. 682), who allows 30,000 to 40,000 trees for a 5-ton factory working 180 to 200 days in the year. Trevor (*Committee on Edible and Oil-producing Nuts and Seeds, Minutes of Evidence* [Cd. 8248], 1916, p. 195) estimates that 50,000 trees would be required for a factory working 10 tons of fruit per day for 200 days in the year.

Exactly what area would be required for, say, 30,000 trees is uncertain. Preuss (*Der Tropenflanzer*, 1902, 6, 464) recommends 60 trees per acre; Milligan (*Cultivation of the Oil Palm*, p. 70) 80 trees per acre; Trevor (*ibid.*, p. 196) considers that 80 trees to the acres is suitable, but that with less than 40 trees per acre the area cannot be worked profitably. An area of about 10,000 acres on the east coast of Sumatra has been planted with about 350,000 oil palms, with coffee as an intercrop. On the whole it appears safe to assume that 80 trees per acre can be grown as a pure crop, and therefore a factory using 5 tons of fruit per day or the produce of 30,000 trees would require an area of 375, or say 400, acres. Smart (*Committee on Edible and Oil-producing Nuts and Seeds, Minutes of Evidence* [Cd. 8248], 1916, p. 115) states that an area of 14 square miles (about 9,000 acres) would be desirable for the establishment of a factory working 10,000 tons of fruit a year, but that such an area in full bearing would produce over 25,000 tons of fruit a year, or 1,000 tons of fruit per annum from 360 acres, which agrees closely with the figure arrived at above. It is obvious that large factories would require considerable areas even under plantation conditions, but that under the present conditions, where the trees are largely wild and irregularly distributed and where it is necessary to allow for bad seasons, the loss of fruit owing to animal and human depredations and other eventualities, a much larger area would be required. From the above considerations it is evident that even a moderate-sized factory must be located in the centre of a large oil-palm area, and that considerable quantities of fruit must be collected and transported over long distances, necessitating a good supply of cheap labour and adequate transport facilities. In some localities navigable waterways may facilitate transport, but

where these are lacking roads suitable for wheeled vehicles or light railways will be necessary, and have in some cases been constructed (*Koloniale Rundschau*, 1910, p. 599). The difficulty of obtaining large and regular supplies of fruit appears to have been met with in the earlier undertakings in the former German West African Colonies. Further, it must be remembered that comparatively small mechanical plant cannot be so economical in consumption of power, in working costs and in skilled labour necessary for supervision, as larger plant; on the other hand, although a large factory may be more economical to work, it would have to be able to draw on a larger area of supply and on a larger supply of labour to collect and bring in the fruit. Even when a suitable site has been secured, further difficulty is likely to be experienced in inducing natives to collect regular supplies for the factory rather than for the production of oil for their own use or for sale in the usual way to traders. These aspects of the question are local and highly important, and in order to deal with them intimate knowledge of the natives, only possessed by those long acquainted with conditions in West Africa, is essential. The chief difficulty so far experienced, and in some cases found insuperable, in connection with palm-oil factories in West Africa, is that of getting adequate supplies of fruits to keep the factories running.

No great difficulty has been experienced in devising machinery for palm-oil manufacture and for cracking palm nuts. Even the machinery first designed and erected appears to have been fairly efficient, and since then numerous improvements have taken place. One point of great importance, which caused considerable trouble in the earlier factories, must, however, be mentioned, viz. the difficulty of obtaining a soft oil of good quality—*i.e.* an oil devoid of an appreciable amount of free fatty acid. According to Fickendey, decomposition of the palm oil is caused by the action of an enzyme naturally present in the fruit pulp (*Der Tropenpflanzer*, 1910, **14**, 366). This enzyme commences to act on the neutral oil directly the fruit pulp is crushed, as in the removal of the pulp from the nuts or during expression of oil from the pulp, and

causes decomposition of the oil into free fatty acid (which contaminates the oil) and free glycerine, which is lost in the washing water.

Fickendey's evidence for the presence of this enzyme is not wholly conclusive, and it is quite possible that the decomposition of the fat is due, partly, at any rate, to the action of micro-organisms. Whatever may be the cause, the fact remains that the oil in the fruit pulp rapidly becomes acid during the course of manufacture unless steps are taken to prevent such decomposition. The necessary steps are simple and consist in the use of fresh fruit, the heating of the pulp to render the enzymes or micro-organisms inactive, and the rapid expression and purification of the oil. The great importance of avoiding decomposition of the oil and loss of glycerine is evident from the relative prices of "soft" and "hard" palm oils, "soft" oils being nearly neutral, high-grade oils, whilst "hard" oils contain a high percentage of free acid, and give a low yield of glycerine (cf. this BULLETIN, 1913, **11**, 215). In normal times the relative prices of such oils are approximately as follows:

Lagos ("soft") oil	£31 per ton
Congo ("hard") oil . . .	£26 per ton

Further, the "hard" oils are at times more difficult to sell even at reduced prices; while the production of almost neutral palm oil is now of greater importance in view of the statements that oil containing less than 1 per cent. of dirt and moisture and not more than 8 per cent. of free fatty acid, can be employed in the manufacture of edible fats, including margarine, and that such oil has been sold at enhanced prices in Germany (*Verhandlungen der Oelrohstoff Kommission*, 1913, No. 1, p. 23).

The preparation of palm oil of low acidity suitable for the manufacture of margarine is the subject of a patent by Bernegau (*German Pat.* 288209/1914). In this process, the fresh fruit pulp is heated *in vacuo* with alcohol in which the "difficultly digestible fatty acids having an irritating action on the mucous membrane, the dark brown colouring matter and pulp water are removed, and edible palm oil is

extracted from the residual pulp by pressing, purified by filtration, and pasteurised, with or without the addition of common salt. The alcoholic liquid is distilled to recover the alcohol while the residual oil is separated from the aqueous layer, and refined by melting to give a product similar to commercial palm oil" (*Journ. Soc. Chem. Indust.*, 1916, **35**, 186). It is probable, however, that much simpler means than this will be used for rendering palm oil edible.

Machinery for the Preparation of Palm Oil

The problem of the mechanical extraction of palm oil has been approached from two standpoints, viz. (1) the construction of small, cheap, portable machines capable of being worked by hand and of being transported from place to place as required, and (2) the erection of central factories dealing with large quantities of palm fruit by means of heavy, power-driven machines.

Hand Machines for the Manufacture of Palm Oil

At least two hand-operated machines, very similar in principle, have been patented for the preparation of palm oil, in both of which the palm fruits are placed in a cylinder with hot water and submitted to the action of beaters, the oil and water being afterwards run off through a grid or sieve. The "Gwira" machine patented by Eglen (*English Pat.* 3357/1909) consists of a horizontal cylinder, either plain or perforated as may be desired, mounted inside a second cylindrical case bearing a hopper at the top; the inner cylinder, which carries a number of fixed blades, is mounted concentrically round a shaft bearing the beater arms or blades which cause disintegration of the fruit pulp. The outer case is fitted with a cock for drawing off oil and water, and is also arranged to turn round the axis of the shaft to allow of the discharge of exhausted material; it may also be used as a steam jacket for heating the charge during working. Trials with the "Gwira" machine were made by Evans on the Gold Coast in 1910 and again in 1912 (see this Bulletin, 1913, **11**, 210). In the latter trials, which were probably made with the modified

type of machine described above, the yield of oil from palm fruits, which were found on examination at the Imperial Institute to contain 22 per cent. of oil, ranged from 13·75 to 16·25 per cent. A specimen of the residual fibrous pulp, which was also examined at the Imperial Institute, contained 30 per cent. of oil, and it appears that extraction of oil is not very efficient, as fibrous residue from the usual native method of preparation contained 31 per cent. of oil. The incomplete extraction is possibly due to the fact that the pulp is not subjected to pressure. The oil produced by the use of this machine is of good quality, and a sample examined at the Imperial Institute proved to be a "soft" palm oil with an acid value of only 10·4.

Another machine in which the palm fruits are beaten in hot water for extraction of the oil is that of Phillips, a native of Lagos; an early model of this machine was patented in 1907 (*English Pat.* 9733) and an improved from in 1912 (*English Pat.* 18370). It consists of a smooth cylinder mounted inside a cylindrical casing and around a shaft bearing beaters. The outer cylinder carries a water tank with a valve to control the flow of water, while the inner cylinder carries on the lower side a sliding sieve to separate the oil and water from the nuts and fibrous waste; this arrangement of the sieve allows its removal so that the exhausted material can be discharged through a space in the inner cylinder. This machine was exhibited at the International Rubber and Tropical Products Exhibition held in London in 1914, and, according to the advertisements issued at that time, it costs £5. Although little is known with regard to the efficiency of extraction of oil by this machine, it should prove useful in economising time and labour in the preparation of palm oil on a small scale, especially by natives.

Power Machinery used in the Manufacture of Palm Oil

A number of different machines for dealing with particular operations, such as removing the fruits from the fruit bunches, separating the pulp from the fruit ("depulping" or "depericarping" machines), nut shelling, and other

purposes, have been designed and constructed, as well as several complete sets of machinery for the preparation of oil and kernels.

The first step in nearly all the methods of manufacture of palm oil is to remove the fruits from the bunches. The fruits constitute about 64 per cent. by weight of the fruit bunches, the residue consisting largely of fibrous stem which would interfere with the process of extraction of oil. Removal of the fruits can be effected by beating the bunches with a heavy stick or against the ground, but at least two machines have been devised for the purpose. Hawkins (*English Pat.* 11618/1912) removes the fruit by placing the fruit heads (with the main stalk upwards) inside a conical metal basket and subjecting them to the action of a plunger, which breaks up the bunch and forces the fruit, etc., through the meshes of the basket into a chamber at the base of the machine. The fruits are here separated from stalk, etc., by an oscillating riddle and a draught of air, and fall through louvres in the bottom of the chamber on to a conveyor which carries them to the other machinery.

A German machine for separating the fruits from the heads is made by G. Luther of Brunswick. From a descriptive illustrated pamphlet issued by this firm, it appears to be necessary to cut up the fruit bunch into three or four parts and to feed the small clusters of fruit to the machine. The clusters of fruit pass first over a sieve which removes fruit already detached, and these pass direct to the final drum sieve (see below), without going through the "beater drum." The clusters of fruit then pass to the "beater drum" (Schlägertrommel), of which exact details are not given, but which probably subjects the clusters to a beating action. The fruits pass on to another sieve which separates the stems of the clusters, and thence to a drum sieve which removes other fibrous matter. The machine is stated to require one attendant and to deal with about 10 tons of fruit bunches in 10 hours.

Following on the removal of fruit from the fruit bunches the processes employed may be divided roughly into two classes: (1) those in which the whole fruits are pressed without removal of the nuts, and (2) those in which the

fruit pulp is removed from the nuts and pressed alone. Proposals have also been made to grind up and press the whole fruits, including the nuts, a mixed palm and palm-kernel oil being obtained. This process, which is covered by a patent (Cookson, *English Pat.* 14728/1911), does not appear to have been worked commercially, and it seems likely that the mixed oil produced would not find favour with users of oil in Europe, while the residual cake, containing much fibre, would be useless except as a manure or for fuel.

(1) *Processes in which the Whole Fruit is pressed (without breaking the Nuts)*

The earliest machinery, of French design, erected at Cotonou, in Dahomey, worked on this principle. The fruits, after removal from the bunches, were heated during 15 to 30 minutes by live steam in cylindrical sheet-metal tanks with false bottoms, and were then transferred to cylindrical presses, of about 130 lb. capacity, and subjected to pressure by means of a hydraulic piston. The first pressing of the fruits separated most of the oil, and the residual mass, on being again heated and pressed, gave a further quantity, the total yield amounting to from 15 to 20 per cent. The nuts were then separated from the exhausted fibrous material in a rotating drum sieve, and were dried and cracked in a centrifugal nut-cracking machine designed by Poisson (Adam, *Le Palmier à huile*, 1910, p. 249). The installation consisted of two tanks for heating the fruit, five presses, two drums for separating the fibre from the nuts, and a nut-shelling machine; the whole plant was worked by a 25-h.p. engine, the boiler being fired with nut shells and waste fibre. Some uncertainty as to the working capacity of this plant exists, as Adam (*loc. cit.*, p. 244) quotes 4 tons of fruit per day, while Hubert (*Le Palmier à huile*, 1911, p. 121) gives the capacity as 2 tons of fruit. In this plant the hydraulic presses appear to have been designed by Paulmier (*Journ. d'Agric. trop.*, 1911, 11, 9), while most of the plant appears to have been constructed by Louis Labarre of Marseilles; Messrs. Fournier et Cie., of Marseilles, also appear to have been

interested in this and other factories in French West Africa. The process possesses the advantage of simplicity, while the preliminary heating of the fruit and the rapidity of working it up, owing to the omission of the operation of removing the pulp, should enable an oil of low acidity to be readily obtainable.

According to a paper read by Hupfeld at the Third International Congress of Tropical Agriculture (London, 1914), the process employed at the Agupflanzung works in Togoland has given good results; and, as it exhibits some original features which may prove valuable, it is briefly described below. Only bunches of ripe fruits should be collected, as unripe fruits give a poor yield and over-ripe fruits contain free fatty acids. The fruit is transported by wagon to the factory and worked up immediately, as any delay causes an increase in the acidity of the oil. The fruit panicles, or small clusters of fruit attached to the main stalk, are removed and heated in boilers by means of steam for about 1 hour at 100° C., in order to prevent the formation of free acid by bacterial or enzyme action. The heated material is then pounded in a stamping mill which forms the special feature wherein this process differs from other mechanical processes employed. The stamping mill, which was devised by Hupfeld and constructed by Messrs. Humboldt of Cologne, consists of a gently sloping, double-walled iron trough heated with steam, in which a row of stamps works on the fruit. These are prevented from touching the bottom of the trough by rubber buffers. The pounding causes the fruits to be loosened from the stalks of the panicles and also thoroughly breaks up the oil-cells of the fruit pulp, while the nuts remain unbroken in the space between the stamps and the bottom of the trough. This stamping process is stated to render only one pressing necessary, whereas in some methods two pressings are needed. The pounded mass, composed of stalks of the panicles, nuts and crushed pulp, is transferred to a steam-heated pan and thence to hydraulic presses, which express the oil in the usual way. The press residue, consisting of nuts, stalks and fibrous waste, is removed from the presses and transferred to a sieve which

removes the stalks, and then to a rotating drum sieve (constructed by G. Luther of Brunswick) which separates the fibre and nuts. The nuts are finally dried in the sun, cracked in a Haake centrifugal machine, and the kernels are separated from the shells by sieves and the use of a brine bath (see p. 76). The fibrous residue still contains some oil, but not in sufficient quantity to render its extraction by solvents remunerative, except perhaps in the case of a very large undertaking. The plant, including engine, is stated to cost about £3,500, and is capable of dealing in 10 hours with 8 tons of fruit panicles or 10 tons of separated fruits. According to Hupfeld, it requires the services of one European manager, two native mechanics and 15 to 20 native workmen. This process is said to yield about 16 per cent. of oil and 10 per cent. of palm kernels. The oil, after being dried in steam-heated vessels, is asserted to contain only 5 to 6 per cent. of free acid, 0·5 per cent. of dirt, and traces of water, and to be suitable for edible purposes, realising before the war about £2 per ton more in Germany than palm oil prepared in the usual way.

Another machine which may be classed among those in which the whole fruit is worked is that patented by Hawkins (*English Pat.* 20061/1912). In this machine the palm fruit is placed in a circular rotating pan or on an endless travelling bed, above which is a framework bearing stationary serrated baffles and pipes for the delivery of steam or solvents, and also heavy rollers for crushing and pressing the fruit in the pan. In operating this machine, the fruits are fed into the circular pan, which, when rotated, causes the fruit to be acted on by the rollers and serrated baffles, steam or solvents or both being used as desired. The baffles, etc., are so mounted that they can be gradually lowered into the pan, and thus disintegrate the pulp thoroughly. The outer wall of the pan is perforated to allow the oil to flow into a surrounding gutter.

This machine is also incorporated in a patent taken out by Hawkins (*English Pat.* 11618/1912) for a process of treating palm fruit. This process consists in removing the fruit from the heads by means of the machine mentioned previously (see p. 66). The fruit is then washed, placed in

baskets, treated with superheated steam, and finally crushed in the machine described above. After removal of the oil, the nuts and fibre are separated by an air blast.

(2) *Processes in which the Pulp is removed from the Nuts before Pressing*

The earliest machinery devised for the manufacture of palm oil, viz. that of Haake of Berlin, was designed to separate the pulp from the nuts before expressing the oil from it. Several plants made by this firm have been erected in West Africa and similar plants have been constructed by other German firms; with the exception of the machine for removing the pulp from the fruits (the "depericarping" machine, or "depulper") the Haake machinery does not call for any special comment, the remainder of the plant being composed of hydraulic presses, sifting machinery for separating the nuts from waste fibre, and centrifugal nut-shelling machines, together with sifting machinery and brine baths for separating kernels from broken nut shells. The depulper consists of a shaft carrying triangular metal blades mounted obliquely on it. The shaft rotates inside a cylinder, which itself rotates in the same direction but at a different speed.

Details are unfortunately lacking as to the machinery erected by the various British firms, who are working concessions in West Africa, but it seems certain that at least one of the firms concerned expresses the oil from the pulp after removal from the nuts.

A machine for removing the pulp from palm fruit has been patented by Buchanan and Tyrell (*English Pat.* 10335/1911), and consists essentially of a stationary elongated, horizontal cylinder, composed of triangular bars sharpened at the edges and so fixed that they can be set at a suitable angle and turned to present a new sharp edge when one becomes blunted. The fruits are fed into the interior of the cylinder at one end, and are acted on by beaters attached to a central shaft which may be hollow to allow of the passage of steam; the pulp, as it becomes detached from the nuts, passes through the spaces between the triangular bars, while the nuts pass out at the end of the cylinder.

A machine for removing the husk from fruit, which has been patented by Dyer and Innes-Ward (*English Pat.* 1873/1914), might be suitable for depulping palm fruit. It consists of a vertical drum, on the inner surface of which pins or knives project. This drum contains a perforated false bottom somewhat smaller in diameter than the drum and attached to a shaft mounted concentrically with the drum, and bearing radial partitions which act as beaters and extend almost to the full width of the drum; these partitions are inclined at an angle to the vertical, so that when the shaft rotates they act as a fan, inducing a down draught which carries off the husk. In operation, this machine is designed to remove the husks from the nuts by the action of the beater partitions and the pins or knives attached to the inner surface of the drum, the husks being carried downwards by the draught into the space between the false bottom and the base of the drum, while the nuts collect on the false bottom and are removed when required. The machine is stated to require about 1½ h.p. to drive it.

Complete plant for the preparation of palm oil in which the pulp is removed from the nuts and then pressed is made by A. F. Craig & Co., Ltd., Paisley, Scotland; A. Olier et Cie., Argenteuil, France; and Louis Labarre, Marseilles. The plant constructed by the first-mentioned firm is known as the Caledonia dry plant, and differs in method of working from most of the existing processes in not steaming or boiling the fruit or pulp with water before expression of oil. It is claimed for this process that neither the fruit nor the oil comes in contact with water, so that even if fatty acid and glycerine occur in over-ripe fruit no glycerine is lost. The process of depericarping is effected by a machine patented by H. G. Fairfax (*English Pat.* 18050/1914). It consists of a table bearing curved ribs and a cover also bearing ribs but curved in the opposite direction to those on the table. In working, the table and cover rotate in opposite directions and at different speeds. The detached pericarp falls between the blades or ribs and is thrown centrifugally into a circular chamber surrounding the table; to facilitate movement of the pulp this chamber is steam-heated. The

nuts are ejected through holes in the lip of the casing of the machine, while any oil set free during depericarping passes through a screen and is collected. The depericarping machine has a capacity of 3 tons of fruit per hour. The nuts, which may still bear adherent pulp, are treated in a second machine consisting essentially of two rollers covered with wire brushes; the nuts are fed from a hopper and pass along grooves in the casing above the brushes and, after treatment by the brushes, the nuts are ejected through spaces in the frame of the machine. This machine is designed to deal with 12 cwts. of nuts per hour (*Engineer*, 1917, **123**, 193). The dry pulp is then cold-pressed in hydraulic presses. In the wet season the fruits are first dried in a special drier, which is also used for drying the nuts so as to render easy the separation of kernels from the shells. In addition to the machinery mentioned, the complete plant supplied by this firm includes a centrifugal nut-cracking machine, combined with an oscillating separator by which the kernels are separated from the fragments of shells by a dry process.

Olier's machine consists of a number of rotating cylinders which carry metal brushes to loosen the pulp. The nuts and pulp are then run into a tilted vat in which they are boiled with water; the pulp is subsequently carried over the side by the flow of water, while the nuts remain in the vat. The pulp is collected on a linen filter, whilst the water (together with a small amount of oil) passes through; it is then heated and the oil removed in cylindrical presses. Finally the nuts are cracked (the type of machine is not stated) and the kernels separated by sieves and by a brine tank. About 25 h.p. is required to drive the larger plant, and 12 h.p. the smaller. The following prices were quoted before the war: plant to work 5 tons of fruit per day (10 hours) £1,000; to work 10 tons per day £1,500, exclusive of boiler and engine.

Another French firm, Louis Labarre of Marseilles, has constructed machinery for several factories erected in West Africa; plant for the factory at Cotonou already mentioned (see p. 67) was constructed by this firm. Exact details of the depulping machinery are not available, and

no mention of nut-shelling machines is made in estimates for complete plant from the constructors, who quoted the following approximate prices before the war: plant to work 2·5 tons of palm fruit per 10 hours, £1,190; for 5 tons of fruit, £2,090 (free on quay at Marseilles); the larger plant requires about 25–30 h.p.

Manlove, Alliott & Co., Ltd., of Nottingham, also make a depericarping machine, as well as a nut-cracking machine, but particulars of these are not available.

Nut-cracking Machinery

The cracking of nuts by hand is a slow and laborious process, generally carried out by native women and children by placing the nuts on a stone and striking them with another stone. It is essential that the nuts shall be thoroughly dried before cracking, as otherwise the kernel is liable to adhere to the shell and to be broken with it. In order to render hand-cracking of palm nuts easier and possible in districts where suitable stones are not available, Birtwistle (*Nigeria Customs and Trade Journal*, 1913, **3**, 291, 324) has recommended the use of an anvil composed of a wrought-iron plate 6 in. square, ⅝ in. or more thick, and either flat or dished in the centre; the nut is struck by a hard-wood or cast-iron circular, handle-less "maul," 3 to 3¼ in. in diameter and 2 in. thick. For convenience in grasping this maul, it is either chamfered down to ¼ in. thick at the rim or the rim is reduced to 1½ in. in thickness, with a groove ½ in. wide and ¼ in. deep to afford a grip for the fingers.

Several small nut-cracking machines have been on the market for some years. With the exception of the Crellin machine (see p. 74) they all operate on the centrifugal principle, in which the nuts are flung violently from a rapidly rotating drum against a hard surface; as these centrifugal machines are identical in principle and only differ in detail, it will be sufficient to describe one of the best known—viz. the Miller machine—in detail. This machine consists of a strong cast-iron framework, bearing a train of gears operated by crank and handle; attached to a spindle rotated by the gearing is a vertically mounted

drum, with two outlets in the rim. In working this machine the nuts are fed from a hopper into the drum through a hole at the centre, and are flung through the outlets in the rim against a strong metal rim mounted concentrically at a short distance outside the rim of the drum. It is essential to keep the speed of the machine more or less constant at about 40 revolutions per minute, for if rotation is too slow nuts pass through uncracked, while excessive speed leads to breaking of the kernels. The labour involved in working the machine is considerable, and some skill is needed to keep it working by hand at an even speed, but power machines can be supplied. The makers guarantee that 92 per cent. of the palm nuts are cracked, and practical trials at the Imperial Institute have shown that this result can be attained; and the small hand machine is capable of cracking about 2 tons of nuts in 10 hours. A good many of these machines are in use in West Africa, and where used they have led to a large increase in the output of kernels.

Small Miller machines for hand working sell in West Africa for about £14 in normal times; the machine is light and can easily be taken apart, and is strongly constructed. With reasonable care it is unlikely to break down, and it also possesses the advantage that it can be used for shelling other oil seeds, such as Shea nuts, Mimusops nuts, etc., by varying the speed of working.

Another centrifugal palm-nut cracking machine has been designed by Poisson; this type is used at Cotonou (Adam, *Palmier à huile*, p. 249).

It is evident that the centrifugal type of machine is regarded generally as being the most serviceable.

The Crellin nut-cracking machine, also obtainable from Miller Brothers of Liverpool, consists essentially of a pair of smooth, tapering, steel rollers, mounted side by side in a sloping position above a pair of fluted, tapering rollers carried in a horizontal position. The palm nuts are fed on to the upper pair of rollers by a sloping tray which is kept in motion by means of cams at the ends of the upper rollers. The nuts pass along the upper tapering rollers until they reach a point where the space becomes

wide enough to allow them to fall through on to the lower grooved rollers between which the shells are cracked. The upper rollers thus serve to feed the nuts on to the cracking rollers at a point where the latter are at a sufficient distance apart for the shells to be broken and the kernels to be left whole. From an experiment at the Imperial Institute with a few pounds of palm nuts, it appears that this machine is somewhat slower in action than the centrifugal type. The machine is strongly constructed and seems unlikely to get out of order even with rough usage, so that it appears to be well suited for use by natives. As packed for shipment it weighs about 305 lb.

Several machines have been devised recently for cracking Cohune nuts (see this BULLETIN, 1914, 12, 237), which are larger and have thicker shells than oil-palm nuts, and as it seems quite possible that these machines, either in their original form or after suitable modification, would be suitable for palm nuts, brief mention may be made of them here.

The Downie machine, designed by Wotherspoon, consists essentially of a depulping device for removing the fibrous pericarp, a centrifugal nut-cracker working in conjunction with an oscillating riddle, and also with a brine bath or with water for separating the broken shell from the kernels. The machine is driven by means of a 5-h.p. oil engine.

Another nut-shelling machine, which might be mentioned here as it is designed to shell "hard nuts, such as the Cohune nut," has been patented by Dyer and Innes-Ward (*English Pat.*, 5687/1913). This machine consists of a mill of the "roller and breast" type, in which the nuts are cracked between a rotating grooved roller and a curved and grooved breast-plate. The breast-plate is fixed to the framework of the machine, while the roller is mounted on bearings working in guides and supported by springs or their equivalent, the compression of which can be adjusted as desired—the object of supporting the roller on springs being to allow it to yield to the pressure exerted by nuts considerably over the average size or by any hard foreign substance. The grooves on the surface of the roller run

parallel to the axis, and are reamered out so that their cross-section is greater than a semi-circle. The machine is said to be capable of dealing with 8 to 10 tons of Cohune nuts per day, and to require 1¼ h.p.

For cracking "Babassu" nuts (*Attalea* sp.), (see this BULLETIN, p. 38), which are similar to Cohune nuts and have extremely hard shells, a machine has been constructed by Messrs. Hind and Lund of Preston. In this machine the nuts are crushed endwise between a fixed steel anvil with a concave depression on the surface and another anvil operated by means of an eccentric device attached to gearing which may be worked either by hand or power. The machine is stated to deal with 40 nuts per minute and is sold at £25 f.o.b. Liverpool (if 100 machines are ordered at one time). The machine as constructed to deal with Babassu nuts would not be suitable for palm nuts on account of the smaller size of the latter, but it might be possible to modify it to suit palm nuts.

Separation of the Palm Kernels from Broken Shells

After the nuts have been cracked the kernels must be separated from the broken shells. This can be effected by the following methods: (1) Hand picking, a method which is only suitable where labour is plentiful and cheap; (2) the use of a brine bath of suitable density (*e.g.* 1 lb. of salt to 1 gallon of water), in which the kernels float and the shells sink; this method possesses the disadvantages of necessitating the subsequent washing and drying of the kernels and the extra cost of using salt, a commodity of some value in West Africa; (3) mechanical means; numerous devices composed of riddles and rotating sieves are incorporated in the various sets of machinery, but, owing to the inherent difficulty of separating such irregularly sized materials as palm kernels and broken nut-shells they require in most cases to be supplemented by the use of the brine-bath method. An ingenious machine has been patented by Smith (Mather & Platt, Ltd., *English Pat.* 24249/1914) in which the kernels and shells are fed on to a travelling belt or lattice passing between revolving cylinders

studded with spikes, and resilient beds of rubber; the spikes on the cylinder serve to pick up the soft kernels but do not penetrate the woody fragments of shell, which are carried away by the belt.

Conclusions

The commercial exploitation on modern lines of the vast tracts of oil palms in the British Colonies and Protectorates and other parts of West Africa may now be said to have commenced in earnest, and is certain to increase in spite of various difficulties. Further development will almost certainly take place along the lines of the "central factory" system, and will probably lead very largely to the manufacture of palm oil and the shelling of palm nuts passing out of the hands of natives, who will find employment in the cultivation of the oil palm and the collection of the fruit for supply to the factories. It is probable, however, that the natives will, to some extent, continue for many years to prepare oil and kernels by primitive methods for their own use and for sale, as is the case in India, where small oil mills have been working for many years. The requirements of the large factories will probably necessitate the planting of large areas with oil palms, and the construction of roads and railways for the transport of produce.

The earlier machinery manufactured by continental firms was often composed of a number of small units, but such plant can hardly hope to compete in efficiency and economy of power and supervision with larger plant, and its installation is not to be recommended except where easy portability of the plant has to be taken into account.

For native use small hand-operated machines for palm-oil manufacture may prove useful, particularly in districts where labour is scarce. Hand-operated nut-shelling machinery also seems likely to prove very useful for native use, as largely increased outputs of kernels are said to have resulted in districts where these are available; they should prove particularly valuable in localities where palm nuts are now allowed to go to waste owing to scarcity of labour, or where the price paid is insufficient to induce the natives

to shell nuts by hand. Plant of British design and manufacture is now obtainable from several firms of oil-mill machinery manufacturers of good repute, and the development of this important West African industry should proceed rapidly.

THE PRODUCTION OF WHEAT IN EGYPT

The following memorandum has been received at the Imperial Institute from Mr. G. C. Dudgeon of the Ministry of Agriculture in Egypt:

In order to establish clearly the position of Egypt among countries contributing towards the cereal supply of the world, it is necessary to enter with some detail into a review of the disposal of the produce under this head for a period of at least a few years. It is impossible to consider the question of the consumption and the disposal of the wheat crop with reference to Egypt without taking into consideration those of maize, rice and millet, which are far more readily substituted for wheat in times of shortage than is generally found to be the case elsewhere. Barley hardly comes into this category, for, although it occupies 7–8 per cent. of the cultivated area annually, the grain is almost entirely used for cattle-food.

More than four-fifths of the total area cultivated in Egypt is capable of growing wheat, but so long as cotton remains the highly remunerative crop it is, there is very little chance of an increase of the area at present assigned to wheat. Indeed, with the abnormally high prices which now rule for cotton, it is probable that the area occupied by that crop will exceed the percentage of 32½ which has been the proportion of the cultivated land occupied by it during the last few years. The restriction of the cotton areas during 1915 and 1916, brought about by the war conditions, allowed a slight increase in the area sown in wheat and a few other cereal crops; but the increase must be looked upon as abnormal, and the extent annually given to the crop may be considered to be 1,300,000 Egyptian

acres.[1] Taking the cultivated land roughly at 5,350,000 Egyptian acres, this represents 24·3 per cent. of the whole. Wheat is grown entirely as a winter crop, and it is doubtful if it could be produced in summer, even if it were possible to provide a sufficiency of water for the land, which, in the ordinary course, is left as summer fallow. Owing to the harvest of the wheat crop taking place in April—May, it cannot advantageously be followed by cotton in the same year, as the latter crop should be sown some months earlier to give the best return. Wheat land, in the rotation employed in the perennial lands, remains fallow until July—August, when maize may be planted, or the land may be left unsown until October or November, when bersim (Egyptian clover) is put in.

In Table I, prepared to show the yields of the four most important cereal crops, including wheat, which are interchangeable, are given the areas, yield in bushels per acre, and production in metric tons, deducting and adding the export and import figures respectively for the season when the crops harvest is taken—that is to say, in the case of the production of 1911–12, for example, the imports and exports for 1912 are taken. This is found to be the best arrangement to arrive at a condition approximately representative of a period common to both. The result, after the latter adjustments, gives an approximation to the annual consumption of each kind of grain in the country. Included in the consumption is the seed used for sowing in the next year as well as all the grain whether grown or imported, which is retained in the country. In the case of wheat the total yield in bushels is also given, whilst in the case of millet, which is of little interest outside the country (as it is rarely exported), the areas and weights of the years' crops only are given.

In this table the Egyptian acre—the feddan—has been used as the unit of area, the ardeb has been replaced by its equivalent—5·444 bushels, and in weight has been taken as the equivalent of 150 kilograms for wheat, 140 for maize, 195 for clean rice, and 135 for millet.

[1] The term Egyptian acre is used in place of feddan, which is equal to 1·038 English acre.

Table I

Season.	Area.	Yield.	Yield per Egyptian acre.	Production.	Year of export and import.	Export.	Import.	Consumption in country.
	Egyptian acres.	*Bushels.*	*Bushels.*	*Metric tons.*		*Metric tons.*	*Metric tons.*	*Metric tons.*
				Wheat				
1910–11	1,237,822	34,939,917	28·2	963,414	1911	5,127	176,020	1,134,307
1911–12	1,282,935	30,339,320	23·6	836,562	1912	1,518	199,720	1,034,764
1912–13	1,305,577	37,278,693	28·5	1,027,905	1913	2,415	243,238	1,268,728
1913–14	1,253,221	32,423,803	25·8	894,036	1914	2,100	88,127	980,063
1914–15	1,533,801	38,636,479	25·2	1,065,342	1915	53,544	34,867	1,046,665
1915–16	1,394,184	36,069,087	25·9	994,551	1916	—	—	—
				Maize				
1910–11	1,544,330	—	37	1,470,200	1911	1,425	5,775	1,474,550
1911–12	1,603,565	—	38·2	1,600,542	1912	885	2,802	1,602,459
1912–13	1,630,189	—	34·4	1,445,715	1913	232	30,081	1,475,564
1913–14	1,689,606	—	38·8	1,698,526	1914	1,059	17,460	1,714,927
1914–15	1,837,516	—	40·4	1,911,060	1915	43,107	38	1,867,991
1915–16	1,782,555	—	—	—	1916	—	—	—
				Rice				
1910–11	227,109	—	32·4	260,108	1911	29,755	38,483	268,836
1911–12	226,010	—	26·6	215,778	1912	25,135	34,342	224,985
1912–13	242,367	—	29	249,975	1913	22,546	54,309	287,738
1913–14	35,629	—	31·6	40,251	1914	13,289	50,318	77,280
1914–15	318,808	—	34·8	398,598	1915	10,595	24,861	432,869
1915–16	144,807	—	—	—	1916	—	—	—
				Millet				
1910–11	228,321	—	—	250,868	1911	Practically no import or export.		250,868
1911–12	229,466	—	—	234,018	1912			234,018
1912–13	222,532	—	—	205,918	1913			205,918
1913–14	242,805	—	—	258,302	1914			258,302
1914–15	276,194	—	—	291,849	1915			291,849
1915–16	238,725	—	—	—	1916			—

NOTE.—Flour is reduced to terms of wheat by taking 85 kilos. of flour as equivalent to 100 kilos. of wheat. Maize flour is not distinguished from wheat flour and is included with the latter.

The table given below (Table II) comprises the sum of the figures in the column of. production of the four important cereal crops dealt with in Table I. compared with the figures for consumption taken from the same table. This shows the deficiency or surplus each year in the country's capacity for self-support, the deficiency having to be made up by importation from other countries, and the surplus enabling exportations to be made.

TABLE II

	1910–11. Metric tons.	1911–12. Metric tons.	1912–13. Metric tons.	1913–14. Metric tons.	1914–15. Metric tons.
Production	2,944,590	2,886,900	2,929,513	2,891,115	3,666,849
Consumption	3,128,561	3,096,226	3,231,948	3,030,572	3,639,374
Surplus = + or Deficit = −	−183,971	−209,326	−302,435	−139,547	+ 27,475

To make adjustments for stocks carried over from one year to another has been found impossible, but it is assumed that a considerable surplus remained to be carried forward to 1916, from the fact that the figure representing the quantity retained in the country was in excess of the average requirements of the four years previous by upwards of 500,000 metric tons. The increase of population would not account for this excess; the assumed annual increment of this being 1·51 per cent. An estimate based on the last census figures and the annual increase mentioned, gives the population for the last six years as follows:

Year.	Population.	Year.	Population.
1911	11,984,713	1914	12,535,859
1912	12,165,682	1915	12,725,150
1913	12,349,384	1916	12,917,300

It is possible that the excess referred to has to some extent been absorbed by the constantly moving military forces in the country.

The conclusion which will be come to from an examination of the matter supplied in this account, is that Egypt, except in circumstances when her most remunerative crop, cotton, has been largely restricted in area, as was the case in 1915, cannot grow enough cereals to supply completely her own necessities. No new lands are likely to become

available for wheat planting in the near future, but much remains to be done in improving the wheat strains and the methods of marketing; and, by a better system of cultivation, it should be possible to obtain average yields from Egyptian soil to compete with the most productive regions of the world. Such a condition, if attained, would permit the country to supply its own requirements but not to export.

THE DISTRIBUTION AND USES OF TITANIUM ORES

TITANIUM has come into prominence largely owing to its application in the manufacture of steel, and, since ores of this metal occur in many parts of the British Empire, a résumé of the information available regarding the distribution of its ores and methods for their utilisation is now given.

Titanium in the metallic form does not occur in nature, but in the form of titanic oxide (TiO_2) it is one of the most widely distributed elements of the earth's crust. Rutile, the commonest natural form of titanic oxide, is rarely found in large deposits, but enormous quantities of ilmenite or titaniferous iron ore carrying varying amounts of titanic oxide occur in many localities, and these two minerals are those which have been used as sources of titanium.

Rutile is known to occur compact or massive in igneous, sedimentary and metamorphic rocks; it varies in colour from yellow to reddish-brown and black, and gives a pale-brown streak. The hardness is about 6·5 and specific gravity 4·2 to 4·3. The mineral usually contains 98 to 99 per cent. of titanic oxide and 1 to 2 per cent. of ferric oxide.

Ilmenite or titaniferous iron ore is an iron-black mineral occurring massive or in the form of thin plates or grains. Its hardness is 5 to 6, specific gravity 4·5 to 5·0, and lustre sub-metallic. The fracture is conchoidal, and streak brownish-red to black. Its composition is represented by the formula FeO, TiO_2, which corresponds to 47·3 per cent. of ferrous oxide and 52·7 per cent. of titanic oxide.

Other minerals containing a large percentage of titanium are *titanite* or *sphene*, which is calcium titanium silicate, and *brookite* and *octahedrite*, crystalline forms of titanic oxide.

Distribution of Titanium Ores

In view of the present very limited utilisation of these ores only those deposits which are or have been worked to any extent, and those within the Empire which are probably capable of being worked, will be described in this article.

Europe

Norway.—The principal rutile-producing deposits in Europe are those of Kragerö, to the north-east of Kristiansund in Norway. The output of rutile from Kragerö for 1912 was reported to be 100 metric tons of material containing 95 per cent. of titanium dioxide, of total value £1,900.

America

Canada.—Ilmenite (titanic iron ore) occurs in great abundance in various parts of Quebec, and is often associated with rutile. Localities of special importance are those of St. Urbain, near Baie St. Paul; Rawdon; Château Richer; near mouth of Rapid River (Bay of Seven Islands); Saguenay River; and shores of Lake Kenogami.

One of the most important deposits is that at St. Urbain, near Baie St. Paul, where there is a bed of ore 90 ft. thick exposed for a length of 300 ft., followed by other outcrops a mile away. The ore is ilmenite associated with rutile.

The deposit was formerly worked as an iron ore. It was also worked in 1910 by the General Electric Co., who used it in the manufacture of electrodes for arc lights. The material quarried contained from 45 to 50 per cent. of titanium dioxide (TiO_2).

An output of 3,596 tons of this titanium ore is reported for 1910. Part of it is stated to have been shipped to the Titanium Alloy Co. of Niagara Falls, N.Y., and used in the manufacture of ferro-titanium.

The deposit near the mouth of the Rapid River (Bay of Seven Islands) is reported to be a large one. The ore here

contains about 34 per cent. of titanium dioxide, but can be enriched by magnetic separation to yield a product containing over 50 per cent. of titanium dioxide.

The black sands of the St. Lawrence are rich in ilmenite.

An account of the deposits of titaniferous iron ore at St. Charles, Quebec, is given on p. 136 of this BULLETIN.

United States.—According to recent reports the only Company producing rutile in the United States is the American Rutile Co. at Roseland, Nelson Co., Va. The rock containing the rutile is stated to be a syenite, in which the mineral occurs as disseminated grains as well as in the form of segregated masses. The rock quarried at Roseland contains on the average 4 or 5 per cent. of rutile. Ilmenite is obtained as a by-product.

In 1914 the output of the American Rutile Co. was 94 tons of rutile containing 95 per cent. of titanium dioxide, and 89 tons of ilmenite containing about 55 per cent. of titanium dioxide.

The output of the Company for 1915 is reported to be 250 tons of rutile worth between \$25,000 and \$30,000, together with a considerable quantity of ilmenite as a by-product.

Asia

India and Ceylon.—Ilmenite is the chief constituent of the crude monazite sands of Ceylon and Travancore. These sands might be expected to yield ilmenite as a by-product at a cheap rate.

Africa

Gold Coast and Nigeria.—Samples of rutile have been received at the Imperial Institute from the Gold Coast and from near Baicossa, about 20 miles north of Obudu Station in Nigeria. The Nigerian material was mixed with ilmenite and was stated to occur abundantly as a loose gravel at the surface.

Nyasaland.—Samples of rutile and ilmenite from Nyasaland have been examined at the Imperial Institute. A sample consisting of a mixture of these two minerals was obtained from veins in gneiss on the Nankande River,

About 50 per cent. of the sample was rutile, and the rest chiefly ilmenite. The sample contained 75·04 per cent. of titanic oxide, 11·86 per cent. of ferric oxide and 11·56 per cent. of ferrous oxide.

Australia

Queensland.—Ilmenite and rutile occur at numerous localities in Queensland, and it is stated that many tons of rutile could be gathered at the mines on the Herberton tin-fields.

South Australia.—Rutile occurs, and has been worked, in the hundred of Talunga, about 6 miles north of Blumberg, South Australia (*Rec. Mines, South Australia*, 1908, 4th edition, p. 356). The workings, which are about 150 yards in length, consist of small shafts and trenches in a kaolinised dyke formation from 10 to 12 ft. wide, striking slightly east of south. Rutile crystals of varying size occur distributed throughout this matrix, and can be extracted by panning. On the surface for some distance on either side of this formation fine rutile can be obtained. The mineral also occurs in a small seam of gravel about 12 in. below the surface. The average yield from these workings amounts to about 1¼ per cent. of the material treated. The deposits appear to have been prospected only to a very limited extent. Nearly 2,000 lb. of rutile were produced at Para Wira in 1907 from 2,000 tons of gravel. Rutile occurs at a number of other localities in this State, but has not been worked.

A notable deposit of ilmenite occurs near Olary, in South Australia. It is associated with uranium minerals and has been worked in recent years as a source of radium compounds. An analysis of a specimen of this ilmenite at the Imperial Institute gave 51·85 per cent. of titanium dioxide, 17·87 per cent. of ferric oxide and 17·37 per cent. of ferrous oxide.

Tasmania.—An alluvial deposit containing rutile is described as occurring on the Westwood Estate, Forth district, Tasmania. Analysis of a sample obtained from this deposit has shown the presence of 91 per cent. of titanium dioxide, whilst a sample sent to the Imperial Institute in 1915 to see

if any market could be found for it proved to be of good and saleable quality.

Western Australia.—Greenbushes, Western Australia, is quoted by the Geological Survey of that State as a locality for rutile.

New Zealand

Titaniferous iron sands occur at a number of places on the west coast of both North and South Islands of New Zealand; the best-known deposits being the Taranaki sands, which extend from Waitotara to the Awakino River in the former island. No estimate of the quantity of iron available in this region appears to have been made, except at Patea, where, it has been calculated, the equivalent of nearly 5½ million tons of iron oxide are available for smelting purposes, not counting the immense amount of low-grade material (containing more than 25 per cent. by volume of quartz, sand or shell-fragments) which would be available if a sufficiently cheap method of concentration were devised (*New Zealand, Mines Statement*, 1914, p. 104). Other workable deposits in this district occur at New Plymouth, Waitara and Mokau.

According to the most recent reports (*Forty-ninth Annual Report of the Dominion Laboratory*, 1916, p. 51), the Patea and New Plymouth sands can be concentrated magnetically to contain 50–60 per cent. of metallic iron. They are rich in titanium, however, containing from 6·2 to 10·6 per cent. of titanic oxide; by magnetic concentration the proportion of titanium is increased slightly relatively to the iron. The amount of phosphorus in the untreated sands varies from 0·16 to 0·28 per cent., and pig iron made from such sands would contain about 0·5 per cent. of phosphorus (see also p. 94).

The Utilisation of Titanium Ores

At the present time the chief use of titanium is in the purification of steel and iron. It is used in two forms: (1) as titanium carbide and (2) as an alloy with iron. The former is prepared by reducing the ore, mixed with carbon, in the electric furnace, the product consisting of microscopic

particles of titanium carbide held in a matrix similar to grey cast iron. Such a material, containing from 15 to 20 per cent. of titanium and known as "ferro carbon-titanium," is the principal form in which titanium is used in steel in the United States at the present time (*Journ. Soc. Chem. Indust.*, 1915, **35**, 55).

The method employed for obtaining the titanium-iron alloy consists in the use of molten aluminium as a reducing agent (Rossi, *Electrochem. Industry*, 1903, **1**, 523). The titaniferous iron ore is charged into a bath of molten aluminium kept fused in an electric furnace. The iron is reduced first and in this the titanium, as it is reduced by the aluminium, dissolves, yielding ferro-titanium. If rutile is used, scrap iron is charged into the bath before the mineral. By this means alloys containing from 10 to 75 per cent. of titanium and only 0·12 to 0·75 per cent. of carbon can be produced in quantity.

Partial analyses of various samples of ferro-titanium are given in the following table (*Mineral Industry*, 1900, **9**, 720):

	No. 1. *Per cent.*	No. 2. *Per cent.*	No. 3. *Per cent.*	No. 4. *Per cent.*	No. 5. *Per cent.*
Titanium	10·28	25·11	35·64	53·92	75·84
Carbon	0·284	0·59	0·75	0·291	0·311
Phosphorus	0·09	0·06	0·06	0·059	0·042
Sulphur	0·01	0·011	—	—	—

A method of concentration to produce an alloy rich in titanium from low percentage titaniferous iron ore has been tried (*Electrochem. Industry*, 1903, **1**, 526). The ore, consisting of 15 per cent. titanic oxide, 80 per cent. iron oxide and 5 per cent. gangue, was smelted in an electric furnace with just sufficient carbon to reduce the iron and leave all the titanic oxide unreduced in the slag. By this means a good quality pig iron was produced and a slag in which all the titanic acid was concentrated. The slag was utilised as a source of titanium for the production of ferro-titanium. Analyses Nos. 4 and 5 given in the above table refer to alloys produced in this way.

Ferro-titanium alloys of German origin are usually produced by the Goldschmidt process, which consists in mixing the oxide to be reduced with finely powdered

metallic aluminium and starting interaction by means of a fuse. A rapid reaction occurs, and the titanic oxide is reduced to the metallic state, the aluminium combining with the liberated oxygen to form alumina.

Titanium is chiefly used for the purification of rail steel, although its use in other steels is growing steadily. The presence of certain elements in minute quantities in steel has a far-reaching effect on its quality; and of these elements nitrogen is one of the most important. According to Braune (*Stahl und Eisen*, 1906, **26**, 1357, 1431, 1496), the effect of nitrogen is at first to increase slightly the toughness and reduce the ductility. Hard steel containing from 0·030 to 0·035 per cent. of nitrogen becomes quite brittle, whilst soft steel loses its ductility when the amount of nitrogen reaches 0·05 to 0·06 per cent. The presence of nitrogen also favours segregation of the phosphorus and sulphur, causing "cold shortness." Dr. Tholander (*Stahl und Eisen*, 1909, **29**, 1594) found that a steel which normally contained 0·012 to 0·022 per cent. of nitrogen on being "overblown" in a converter for three minutes, contained 0·032 per cent. of nitrogen.

The removal of the greater proportion of the nitrogen normally found in steel is a matter of much importance; and it is stated that this can be attained by the use of titanium, which combines with nitrogen at a temperature of 800° C. to form titanium nitrides. Titanium has a melting point of 1,850° C. and a specific gravity much less than that of iron; these physical properties preclude the use of titanium itself, and lead to the use of the carbide or an alloy of titanium and iron instead of the pure metal, which would float on the fused steel and be difficult to dissolve. Exhaustive experiments with titanium alloys have shown that the best results are obtained with an alloy containing from 10 to 15 per cent. of titanium. The steel works in the United States which employ ferro-titanium specify an alloy of this composition.

The alloy is added just as the steel runs into the ladle, *i.e.* after recarburisation and the addition of the necessary ferro-manganese and ferro-silicon. An instantaneous reaction occurs, and after a short time the slag formed by

the reaction (chiefly titanic oxide) rises to the surface. According to the experience of E. von Maltitz, the addition of one-half per cent. of ferro-titanium, containing 10 to 15 per cent. of titanium, *i.e.* a maximum consumption of 1·7 lb. of titanium per ton of steel produced, is sufficient in most cases to purify steel for rails to the desired extent. The beneficial effect of titanium alloy in preventing segregation of the sulphur, phosphorus and carbon, and in concentrating the blowholes in the pipe cavity, has been demonstrated by the experiments of many well-known metallurgists in America. Improvement was also noticed in the working of the steel in the rolling mill. The rails produced were found to give much better service than ordinary Bessemer steel rails (*American Soc. for Testing Materials*, 1910, **10**, 201). Tests on steel rails laid at a crossing at a New York Railway Station showed that in six months the steel treated with ferro-titanium had lost by flange-wear less than one-third of the amount lost by the Bessemer rails which preceded them. Interesting comparative tests have been carried out by the Baltimore and Ohio Railway. The plain Bessemer rails contained 0·55 and the titanium-treated rails 0·48 per cent. of carbon; each rail weighed 90 lb. to the yard. After five months' wear on a heavy curve, the plain Bessemer rails had lost 4·18 lb. per yard, whilst the titanium-treated rails had only lost 1·45 lb. per yard. The Bessemer rails showed excessive wear and the usual indications of segregation, whilst the treated rails were solid and homogeneous (*Times*, Eng. Suppl., 1909, May 26).

On the Boston Elevated Railway titanium-treated rails laid alternately with plain rails of practically the same composition showed 41 per cent. less wear after 214 days' service. Similar results were obtained in tests on the Rock Island Railroad, where it was found that after 17 months' use titanium-treated rails had 0·014 sq. in. abraded from their sections, on the average, while electric steel rails showed under the same conditions a loss of 0·058 sq in. and ordinary rails 0·075 sq. in. (*Journ. Soc. Chem. Indust.*, 1915, **34**, 57).

The quantity of titanium-treated steel rail produced in

the United States during recent years has decreased considerably, as shown by the following figures:

	Tons produced.		Tons produced.
1909	35,945	1913	47,655
1910	256,759	1914	23,321
1911	152,990	1915	21,191
1912	141,773		

The decrease is said to be due to the fact that most of the steel previously treated was Bessemer steel, whereas this is but little used now in the United States for heavy rails, and the open-hearth steel does not appear to benefit by treatment with ferro-titanium to the same extent as Bessemer steel.

In 1910 an order for 41,500 tons of titanium-treated steel was given by the New York Central lines, where rails of this type had been under trial for several years. On these lines the rails are subject to great variations in temperature, which often falls in winter to 30° below zero. The results of tests on rails employed on various sections of this line are given in the *Journ. Indust. Eng. Chem.* (1910, **2**, 299).

The beneficial effects of using titanium alloy for purifying basic open-hearth steel were demonstrated by experiments carried out in the Osnabrück Steel Works (*Stahl und Eisen*, 1910, **30**, 651). In every case the bars treated with alloy showed increased strength, the fracture showing a fibrous structure similar to that of forged iron. In bending tests the titanium-treated steel also gave results superior to those obtained with untreated steel. Improvement was even seen with the addition of such a small quantity of titanium as 0·04 per cent.

In addition to the above-mentioned uses for ferro-titanium as a purifier for steel, it is stated that certain manufacturers of crucible steel in the United States are adding the alloy in sufficient quantity to retain 0·05 to 0·20 per cent. of titanium in the finished steel. The addition of this is said to increase the toughness and durability of the tool steel produced.

Titanium-iron alloy, containing 5·8 per cent. of carbon, is also used to some extent for improving the quality of iron by removing occluded gases and preventing segrega-

tion of subsidiary constituents. The quantity added varies from 1 to 3 lb. of 10-per-cent. ferro-titanium to each 1,000 lb. of metal. It has been demonstrated by the experiments of Dr. R. Moldenke that the improvement is most noticeable in machinery pig (grey) iron (*Trans. Amer. Founds. Ass.*, 1908, 17, 57). These experiments showed that the average crushing strength of machinery pig iron was increased 52 per cent. by the use of 0·5 per cent. of the ferro-titanium alloy.

Results indicating similar improvements have been recorded when the alloy is added to metal for chilled car wheels, rolls, and to malleable iron. In the case of chilled car-wheel iron, the titanium treatment increases the crushing strength considerably.

An alloy of copper and titanium, containing from 5 to 12 per cent. of the latter element, is stated to be valuable for addition to copper castings (*Min. and Sci. Press*, 1909, 99, 355). A. J. Rossi recommends the addition of 1 to 2 per cent. of this alloy to the molten copper, as it enables the copper to be cast in sand without difficulty, eliminates oxide and absorbed gases, and gives the metal a close-grained dense structure free from blow-holes.

Cupro-titanium is now finding a use in the United States for degasifying copper and its alloys, and an alloy containing copper 93 per cent., titanium 5 per cent. and magnesium 2 per cent. is stated to be still more effective for the purpose. The physical properties of aluminium bronze are said to be considerably improved by treating the alloy with titanium. The treated alloy is stated to equal phosphor or manganese bronze in strength, to be considerably lighter and little affected by sea-water.

Another form in which titanium is used for purifying metals is that known as "titanium thermit." This consists of a finely powdered mixture of metallic aluminium, oxides of titanium and iron, enclosed in a tin, which is attached to an iron rod and introduced into the ladle immediately after the metal is run from the surface. Its function is similar to that previously described for ferro-titanium, the oxides of titanium and iron being reduced to the metallic state by interaction with the metallic aluminium.

Alloys of titanium and silicon are also made for use in the steel industry where it may be desirable to add both these elements. These alloys can be produced containing 5 to 70 per cent. of titanium and 20 to 75 per cent. of silicon by reduction in the electric furnace of suitable quantities of silver sand and pure titanic oxide (*Journ. Soc. Chem. Indust.*, 1910, **29**, 636).

Pure titanium, which has a melting point of about 1,850° C. and a specific gravity of 5·17, does not appear to have been put to any industrial use as such.

Smelting of Titaniferous Ores

Closely connected with the general question of the utilisation of titanium ores is that of the use of iron ores containing small quantities of titanium. The objections made by iron smelters to the use of such material are not that it produces an inferior quality of iron, but that it gives pasty slag, and that the aggregations of titanium nitride and nitrocyanide in the furnaces render working difficult. It is also stated that more fuel is necessary than in the case of non-titaniferous iron ore.

In the past, highly titaniferous iron ores have been successfully smelted in various localities. An iron company which had works at Norton, near Stockton-on-Tees, many years ago smelted successfully an ore containing 39·2 per cent. of titanic oxide to yield forge iron (*Trans. Amer. Inst. Min. Eng.*, 1882, **11**, 159). The fuel and fluxes employed were about 17 cwts. of coke, 12 cwts. of limestone, and 3 to 4 cwts. of basalt or similarly fusible silicate per ton of ore. Owing to the uncertainty of the supplies and the small quantity of iron in the ore the work was abandoned.

The question of the smelting of titaniferous iron ore is thoroughly discussed, and the results of many important blast-furnace experiments quoted in an article by A. J. Rossi (*Trans. Amer. Inst. Min. Eng.*, 1892, **21**, 832), where he shows that it is possible to obtain a good pig iron and a fluid slag from ores containing 20 per cent. of titanic oxide.

Iron ore fairly high in titanic oxide was formerly mined and smelted in Sweden, but the production is stated to

have ceased in 1904. In the larger of the Swedish furnaces which smelted this ore, the consumption of fuel is stated to have averaged 275 bushels of charcoal to the ton of ore, a consumption considerably in excess of that required for non-titaniferous ore (*Eng. Min. Journ.*, 1904, **78**, 350). Ores carrying a high percentage of titanium were successfully smelted in blast furnaces during a period of 20 years in the Adirondack Mountains, New York State (*Stahl und Eisen*, 1909, **29**, 1593); the ores from this locality rarely contain less than 8 per cent. and often as much as 15 per cent. of titanic oxide (*Min. Res. U.S.A.*, 1908, Pt. I, 91).

J. T. Singewald (*Bulletin* 64, 1913, *U.S. Bur. Mines*) has investigated the possibility of utilising the titaniferous iron ores of the United States and concludes that, for the present at all events, the outlook on the whole is not promising, although there are two large high-grade deposits, at Sanford Hill, in the Adirondacks, N.Y., and Iron Mountains, Wyoming, which are readily accessible and their utilisation within a few years seems certain. Experiments on the magnetic separation of the ilmenite from the magnetite in the ores gave varying results, but in some cases it was possible to prepare concentrates that required the admixture of only a small proportion of non-titaniferous ores to make a satisfactory ore mixture.

In 1914 an attempt was made to utilise the Sanford Hill ore, which consists approximately of two-thirds ilmenite and one-third magnetite. By treatment with Wetherill separators a concentrate was obtained containing about 55 per cent. of iron and $11\frac{1}{2}$ per cent. of titanium. This was smelted in a blast furnace with magnetite in proportions varying from $\frac{1}{16}$ to $\frac{5}{16}$ of the total charge, and, contrary to the usual assertion, it is stated that the slag was unusually fluid and the fuel consumption normal (*Min. and Sci. Press*, 1914, **109**, 983). It was found difficult to make pig iron containing 2 per cent. of silicon or over, as there is a tendency for titanium to replace silicon; malleable pig iron made from a charge containing $\frac{5}{16}$ of titaniferous concentrate contained 0·5 per cent. of titanium.

The iron ore smelted by the natives of the Salem district, India, by the Catalan process, is stated to carry a certain

amount of titanic oxide (*Rec. Geol. Surv. India*, 1892, 25, 139).

It was reported in January 1916 that an ore carrying 7 per cent. of titanium dioxide was being smelted for iron at Belleville, Canada.

The possibility of utilising the deposits of titaniferous iron ore at St. Charles, Quebec, by means of electric smelting has been discussed recently by Prof. A. Stansfield; a résumé of his conclusions is given on p. 137 of this BULLETIN.

Several attempts have been made to smelt the Taranaki iron sands of New Zealand (cf. p. 86), but great difficulty has been met with owing to the physical nature of the ore and the amount of titanium present. In 1892, 45 tons of pig iron were made at Onehunga, near Auckland, by a process devised by Mr. E. M. Smith, in which the sand is briquetted with clay before smelting. Samples of steel made at Onehunga from the Taranaki sand are exhibited in the New Zealand Court of the Public Exhibition Galleries of the Imperial Institute. The pig iron made by this process contained too much phosphorus and sulphur to be used in the acid Bessemer or Siemen's processes, but otherwise it was of good quality. Although the prospects of the industry were favourably reported on at the time by various experts, including Mr. G. N. Snelus, F.R.S., efforts to raise capital to work the deposits were unsuccessful (see *Bulletin, No.* 14 (*New Series*), *Geol. Surv. Branch, Dept. Mines, N.Z.*, 1912, pp. 48–51).

More recently a process has been devised in which 60 per cent. of iron sand is briquetted with 40 per cent. of small coal from the Liverpool State Colliery, and the briquettes coked before smelting. An experimental blast furnace was erected near New Plymouth, and 3 tons of pig iron were produced in 1914. This, however, like that made by Smith's process, was above the Bessemer standard in phosphorus, but the titanium contained in the iron sand was largely eliminated in the furnace. No further information as to the quality and analysis of the pig iron is available (see *N.Z. Mines Statement*, 1914, p. 26).

From a review of the literature on this question it would

appear that under suitable conditions the smelting of iron ores containing a moderate percentage of titanium should be a commercial possibility, especially as there are enormous quantities of such ore, which is usually very low in phosphorus, obtainable at a low price. Titaniferous iron ore containing about 7 per cent. of titanium has been smelted directly to steel in the electric furnace on a small working scale in Canada (*Can. Min. Journ.*, 1912, **33**, 448), and the successful utilisation of such ores may perhaps be looked for in this direction rather than by smelting in blast furnaces.

Other Uses for Titanium

The employment of titanium carbide as an electrode for arc lighting has been suggested, but it is not much used for this purpose alone, as the light is of a yellow character, and the operating costs are high. According to *Trans. Amer. Electrochem. Soc.* (1909, **16**, 217) this substance gives a high candle-power efficiency. It has been found that the titanium carbide arcs are most satisfactory when operated on a constant current circuit. The electrodes are prepared by grinding the carbide to a fine powder, mixing with a suitable binder and forcing the paste through a nozzle by means of a hydraulic press. The rods so produced are cut into suitable lengths and dried, first in the air, then in a gas oven, and finally in an electric furnace of the carbon-tube pattern. The electrodes are plated with copper to prevent oxidation during burning. The characteristics of the titanium-carbide arc light are an extremely luminous inner path, very little light from the outer mantle, and none from the craters. The carbide is used as the cathode, the anode being a rod of copper or carbon. Electrodes of the sub-oxide of titanium prepared by the reduction of rutile have also been tried for arc lighting, but with no great success. The electrode containing titanium which has been most extensively used is that employed in the so-called "magnetite" arc lamp. This electrode is composed of magnetite, with 15 to 20 per cent. of rutile, and some chromite; the first-named giving conductivity to the electrode, the second being the light-producer, and the last adding to

the life of the electrode. This lamp, which first found favour in the United States, is now employed to a limited extent in this country (see also Eng. Pat. 2,027 of 1909 for improvements in manufacture).

According to English Patent 18,220 of 1912 a "luminous" arc electrode is prepared from a mixture consisting of titanium carbide 96 per cent., copper oxide 3 per cent., and lithium fluoride 1 per cent. Another mixture for this purpose consists, according to U.S. Pat. 1,112,458 of 1914, largely of carbon together with some calcium titanate, an organic salt of titanium and a titanium halogen compound or alkali titano-fluoride. The use of cerium titano-fluoride is covered by Eng. Pat. 13,988 of 1912. The light is steadied by the addition of potassium or sodium fluoride, and barium fluoride is added to correct the colour of the flame. A mixture for "luminous" arc electrodes may contain carbon 45 per cent., cerium titano-fluoride 35 per cent., potassium fluoride 10 per cent., barium fluoride 10 per cent. To the mixture is added a small quantity of either silicate, borate, carbonate, tungstate or molybdate of sodium in order to minimise the etching effect of the fluorides on the glass globes. Titanic oxide mixed with calcium cyanamide, cryolite and carbon is suggested in Eng. Pat. 11,792 of 1912. Fused oxides of titanium, tungsten and rare earths in molecular proportions are suggested in U.S. Pat. 1,161,173 (1913).

Titanium itself has been suggested and tried to a limited extent as a material for filaments for electric glow lamps, the processes of manufacture and use being covered by numerous patents. It is claimed that such filaments give a high candle-power efficiency, and are less sensitive to variations in voltage than other filaments. A trial lot of about 1,000 of these lamps was produced in America in 1906 (*Mining World*, 1910, **33**, 230). A suitable means for the production of such filaments is to force a colloidal solution of titanium hydroxide through a small nozzle, and after drying the fine thread thus produced to reduce it in hydrogen to the metallic state. It is interesting to note that should there be the slightest trace of carbon present in the filament, such as may get in it from the vaporised oil

from the pump during exhaustion, the efficiency of the lamp will be so impaired as to be practically useless (*Electrician*, 1907, **58**, 892).

A process for obtaining pigments from titaniferous iron ore, such as ilmenite, has been described (*Journ. Soc. Chem. Indust.*, 1910, **29**, 1,023). The ore is roasted at a temperature below incipient fusion and crushed in water, yielding a finely divided product of a yellow to red colour. Light yellow pigments, stated to be suitable for use in rust-preventing paints, are made, according to Eng. Pat. 10,368 of 1911, by digesting titaniferous iron ore with sulphuric acid and then roasting the mass at a temperature high enough to decompose the sulphates.

Rutile is sometimes added to porcelain tiles to give a soft yellow underglaze colour, and it finds a similar use in the manufacture of artificial teeth. Only the purest varieties can be employed for the latter purpose (*Min. Res. U.S.A.*, 1906, 530).

Pure titanium compounds, particularly the oxalate and the double ammonium oxalate, are used to a limited extent as mordants (*Mining World*, 1910, **33**, 230). They are stated to give with tannin a yellow colour of great durability. Titanous chloride has been used as a mordant and the sulphate as a mordant and "stripper." The double pyrophosphates of titanium with the alkali metals are stated to be capable of application to textiles without damage to the latter.

The use of titanium salts as mordants for textiles is discussed in the *Journ. Soc. Chem. Indust.* (1896, **15**, 420, and 1899, **18**, 15). At present their use for this purpose seems limited.

Titanium potassium oxalate is now used on a fairly considerable scale for staining and dyeing leather, and it is particularly useful for chrome-tanned leathers, producing shades of colour which are extremely fast to light and alkalis (*Leather World*, 1916, **8**, 15).

Titanous chloride and sulphate are stated to be finding an extended use in the textile industry on account of their great power as acid-reducing agents. Titanous chloride is used in laundries for removing iron stains

and for clearing coloured goods that have "run" in the wash.

Titanium lactates were advertised, before the war, under the name of "Corichrome" as mordants and "strikers" for use in the leather industry. The preparation of these compounds is described in Eng. Pat. 22,629 of 1901, 23,188 of 1901, 14,921 of 1902, 27,597 of 1902, and a full account of their uses is given in *Leather Trades Review* (1913, 46, 183 and 266).

It has been suggested that titanium nitride, which is produced during the smelting of titaniferous iron ore, might be utilised as a nitrogenous manure, but experiments do not seem to have been made to test the availability of this compound for agricultural purposes.

MOTHER-OF-PEARL SHELLS AND THEIR USES, WITH SPECIAL REFERENCE TO THE AUSTRALIAN INDUSTRY

During recent years several consignments of mother-of-pearl oyster shells have been received at the Imperial Institute from various sources for exhibition purposes and, as the demand for these shells in the button and knife-handle trade is considerable, it will be useful to give an account of their sources of supply, distribution, and economic qualities. Much of the information has been kindly furnished by Dr. H. Lyster Jameson.

Sources of Shells

The two principal species of pearl oyster furnishing mother-of-pearl are the large mother-of-pearl oyster (*Margaritifera maxima*, Jameson) and the black-lipped mother-of-pearl oyster (*Margaritifera margaritifera*, Linn.).

The large mother-of-pearl oyster inhabits the tropical coasts of Australia, Papua, the Solomon Islands, the Dutch East Indies, the Sulu Archipelago and other localities in the Philippine Islands, Borneo, and the Mergui Archipelago.

Two principal types are recognised in the trade, viz.

gold-lip and silver-lip. The former is characterised by a more or less golden colour of the margin of the nacreous portion of the shell. This gold colour detracts from the value of the shell, as the silvery-white colour is most in demand for the best class of articles, such as knife handles and large buttons, so that gold-lip shell realises a lower price on the average than silver-lip. The principal sources of the silver-lip variety are Queensland, Western Australia, the Northern Territory, and the Ara Islands, the remaining localities mentioned above being characterised by the large preponderance of gold-lip shells that they yield.

M. maxima was formerly obtained in large quantities in shallow water by naked divers, and was even picked up by waders at low water, but is now chiefly fished for in deep water of 10 to 40 fathoms with the aid of the diving dress.

The price of this shell in the London market varies from £70 per ton upwards according to quality, the highest prices being paid for bold, clean shell, that is free from the attacks of boring animals, and calculated to yield the largest number of such objects as knife handles with the minimum of waste. Occasionally selected parcels reach a price exceeding the rate of £500 per ton; but £150 to £200 per ton may be taken as an average price for shell of good quality.

The typical form of the black-lipped mother-of-pearl oyster (*M. margaritifera*, Linn.) occurs around the tropical coasts of Australia and throughout the East Indies, being particularly partial to coral reefs and atoll lagoons. It is usually fished for in these waters by primitive methods, such as naked diving or wading on the reefs. The output is relatively small, and most of the supplies, unlike those of the more valuable *M. maxima*, are purchased in small quantities by traders from the natives who collect them. Farther east among the coral islands of the Pacific this species is represented by a larger and darker variety (*M. margaritifera* var. *Cumingii*, Reeve) known in the trade as the Tahiti, Gambier, or Penrhyn shell.

The price of black-lipped shell fluctuates greatly with the demand for "smoked pearl" buttons, fashionable for

ladies' tailor-made clothing: the dark colour occurs on the lip of the shell and on the outer surface of the nacre. Occasionally the best qualities have reached prices exceeding those of the great white shell (*M. maxima*), but, as a rule, the average price does not exceed £60 per ton.

The Zanzibar shell (*M. margaritifera* var. *zanzibarensis*, Jameson), with copper-coloured margin is the East African representative of the species, while on the west coast of tropical America it is replaced by a paler form (*M. margaritifera* var. *mazatlanica*, Huxley) which is used as a cheap substitute for *M. maxima*.

Other local varieties of this species are *M. margaritifera* var. *persica*, Jameson, from the Persian Gulf, known in the trade as the "Bombay shell" from the port through which it is shipped; and *M. margaritifera* var. *erythreae*, Jameson, or the Egyptian shell from the Red Sea. Both these varieties are large, bold, light-coloured shells, and are used for purposes similar to those for which *M. maxima* is valued.

It will thus be seen that *M. margaritifera* with its varieties is very widely distributed in the Indian and Pacific Oceans; and that, while *M. maxima* occurs in an area where the character of the water is to some extent influenced by the proximity of numerous islands with a heavy rainfall or with large rivers like the Fly River in Papua, the range of *M. margaritifera* is much more extended, and the shell reaches its maximum development in areas of high salinity, far removed from river influence, as, for example, in the atolls of the Pacific: it is, in fact, much more an oceanic form than is *M. maxima*, though occurring sparingly in the haunts of the latter. The economic bearing of this point has been emphasised in a paper, "Biological Science and the Pearling Industry," by Dr. H. Lyster Jameson (*Knowledge*, November 1912, pp. 427-430), in connection with the unsuccessful attempts which have been made to establish *M. maxima* in atoll waters.

A less valuable source of mother-of-pearl is the Sici or Trocas shell (*Trochus niloticus*) which is of common occurrence all over the Fiji group of islands. These shells are gathered chiefly from the top of the sea-reef, few being

found where the waves break or on the shore edge of the reef. They are taken in calm weather by diving. After a patch of reef has been worked a further collection can be made within a few days. This, together with the fact that specimens are taken on the seaward side of the reef, appears to indicate that these molluscs come up from deep water where probably they breed. Sici shells are worth from about £12 to £45 per ton according to size and condition, and are exported chiefly to France and Japan for button-making.

Among other shells used instead of mother-of-pearl may be mentioned the green snail shell (*Turbo marmoratus*) and the green ear and Ormer shell (*Haliotis tuberculata*).

Method of Collection

Fishing for pearl oysters is now largely carried on by means of highly organised fleets of vessels. Such a fleet usually consists of a schooner or other large vessel of 100 to 200 tons on which the manager resides, and a number of fishing boats or luggers ranging from 10 to 20 tons, each equipped with a diving dress and pump. The oysters are fished by the luggers and brought on board the schooner or floating station by motor launches, and are then opened in the presence of the manager. Any pearls found are extracted, and the shells are then cleaned, marine growths being removed from their exterior and the brittle fawn-coloured lip chipped off. They are afterwards sorted into grades and packed in cases, when they are ready for shipment to the London markets for disposal by auction at the periodical shell sales.

In some instances the boats are entrusted to divers who, while normally servants of the owners, are for all practical purposes the lessees of the boats. The diver has to feed and remunerate the crew, and receives a "lay" of so much per ton of shell delivered to the owner. In such cases any pearls that are found become the perquisites of the diver.

Commercial Uses

The largest and steadiest consumption of mother-of-pearl is in the button trade, and much is also consumed by cutlers for handles of fruit and dessert knives and forks and pocket knives. It is also used in the inlaying of Japanese and Chinese lacquers, European lacquered and papier-mâché work, trays, etc., and as an ornamental inlay generally.

About 85 per cent. of the shells marketed are used for the button trade, the chief centres of which are Paris and New York. In the latter centre the chief demand is for Manilla shells which, although consisting of a very large proportion of gold-lip and being therefore rather wasteful, have the reputation of being appreciably harder.

The average size of the shells collected is from 5 to 6 in. in diameter, as it is in these that the best pearls are found. The species *M. maxima*, however, is occasionally taken with a diameter of 12 in. and a weight per pair of 10 lb.; the usual weight of the 5 and 6 in. shells is from $\frac{3}{4}$ to $1\frac{1}{4}$ lb. per half-shell, or about 2,000 to the ton. Their age varies from 4 to 6 years, according to the size.

The supply of shells is said to be inexhaustible, there being vast beds in the deeper waters of the Gulf of Carpentaria and Torres Straits inaccessible to divers. At present the average catch is about 4 tons per lugger per annum.

The commercial value of each shell depends mainly on its shape, colour, and freedom from worm holes. The following account which applies to the true mother-of-pearl shells (*Margaritifera* spp.) has been compiled from information kindly supplied by Mr. F. W. Brunning.

Colour.—The nacreous portions of the shell should be silvery white in colour with an iridescent sheen. Some shells have a yellow margin of considerable depth and density of colour, and this detracts from their commercial value. Shells that are slightly yellow, that is where the top of the lip is only touched with that hue, can be accepted, provided that the proportion of such shells in any parcel does not exceed, say, 5 to 10 per cent.; but a yellow band

extending about half-way down the knot affects the value of the shell in a greater degree; while those with the yellow margin extending from the knot to the wing are worth still less, as the yellow portion has to be cut away.

Shape.—In shape the shell should be as flat as possible, wide in surface, and not too heavy in the knot and butt (or hinged part). A shell shaped like that shown in Diagram I, with the wing extending from A to D, is a good wide-winged shell; if in a shell of similar form the wing extends only from A to C it is a medium wing, and the shell loses some of its value for first-class work; but if the wing extends only from A to B, the shell is said to be short-

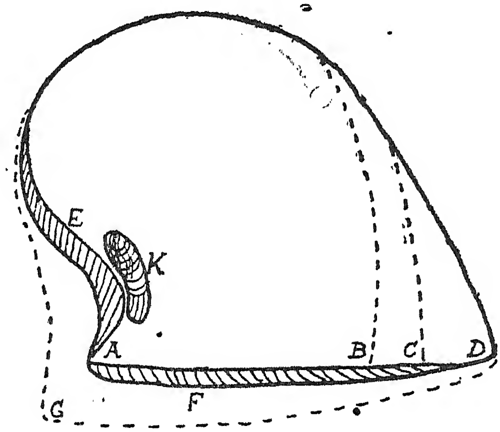


DIAGRAM I.—Illustrating the various shapes and grades of mother-of-pearl shells. E = knot, F = butt, K = knuckle; for explanation of other letters see text.

winged, and is of little value for work requiring a broad expanse of wing.

Strength, etc.—A good shell should be well balanced or proportioned and should show a knot and butt in proportion to its size, as indicated by the positions of E and F in Diagram I. If the knot and butt should meet at G instead of at A, the shell is heavy-knotted or -headed. When a shell is short-winged, the knot and butt portions are generally thicker than when the shell is wide- or medium-winged; and as the knot and butt portions are generally waste such shells are of less commercial value than the others. A shell should have its strength or thickness spread over the whole surface, and not confined

to the base; that is, it should not be very thick about the handle part (shown in the Diagram II at H) nor thin off rapidly to the centre, so that the edge all round is thin like a knife and in many cases shews a bluish colour towards the edge. The handle part should be "meaty" or strong and not have depressions or pits (known in the trade as "thumb-holes"). Flat shells naturally suffer less in this respect than do cup shells, some of which are far too curved or cupped to be used for the same purposes as the flat shells. Just inside the knot is the knuckle (Diagram I, K) and, if the knot is heavy, the knuckle is generally very pronounced, and the shell falls away here in a hollow.

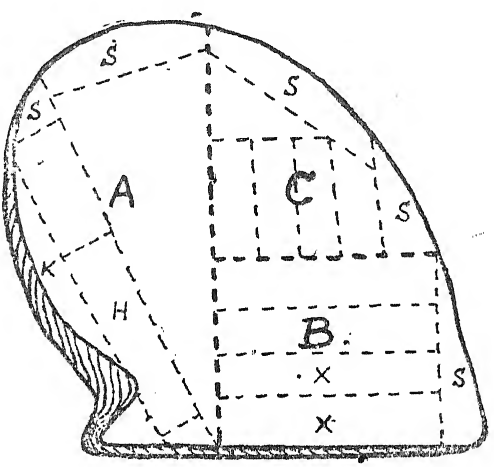


DIAGRAM II.—Illustrating method of cutting mother-of-pearl shells.
Part A is used for best handles, stilettos, etc.; B for small handles and scales; C for small scales, buttons, etc.; H = handle cut; X = best scales; K = knot, used for common work, *e.g.* crosses and beads; S = skirt, mostly waste.

In some shells these knuckles stand up like a wall, and the shell itself at the base of the wall is thin right away to the edge. There is no substance in such shells, and they are described as "consumptives." This condition is more often found in short and "stumpy" shells than in medium or wide-winged shells.

For superior work the flattest and best-proportioned shell is necessary. The thick-dotted lines in Diagram II show how a shell is sized up; for cutlery and scale work parts A and B are the chief portions employed, and part C is used for whatever it may be strong enough. When a

shell is too poor for any other purpose, it is used for button making, and for this industry all grades of shells can be used, according to the size and quality of button required, and to the locality of the industry.

Defects.—One of the principal defects in shells of this class is the presence of worm holes, and such shells can be used only for buttons. These holes are sometimes so small that they can be detected only on close examination, and often not until after the shells have been cut up and a good deal of labour expended on them. Another common defect consists in a crease in the edge of a shell, generally in the wing portion, as though the shell had been made soft and punched with some tool. This defect—caused, it is believed, by a turtle bite—considerably affects the commercial value of the shell.

Uses.—For best or fancy work a shell is cut in any way required for the particular work in hand, but for the cutlery and scale trades it is usually dissected as shown by the dotted lines in Diagram II. Here Section A is the most valuable, as from this part the pearl handle is cut, its value being proportional to its size. Section B is called the wing, and is sometimes stout enough to produce small handles; otherwise it is utilised for scales, whose value again is proportional to their size and length. Section C is used for smaller grades of scales or, if too poor for this purpose, is sold for button making. Section A, after the best handle has been cut out, is used generally for smaller handles or scales according to the strength of that particular part: the smallest handles are known as "stilettos," and are used for ladies' manicure and work-basket sets. If pearl razor scales are in demand the shell, if suitable, is cut differently so as to obtain a long straight piece, as also is the case where paper-knives and book-covers are required. Shells that can be used for these purposes are known as best or fancy shells.

As to the value of the shell a great deal depends on the demand for any specific article. When large handles are not in demand, sound, heavy shells are not required by the cutlery trade, though shells giving medium to small handles might be acceptable: at the same time the heavy shells

might be required by the fancy trade. The main object in cutting up shells is to get as much out of them as possible, the manufacturer doing this according to his own ideas and requirements. In this trade the profit is earned mainly, if not entirely, in handles between 2 in. and 3 in. in length, larger sizes being usually unsaleable.

The Trade in Australian Mother-of-Pearl Shells

At one time the chief Australian State producing mother-of-pearl shell was Queensland (see an earlier article on "The Australian Pearl-Shell Fishery" in this BULLETIN, 1906, 4, 40), but during recent years most of the shell exported has been shipped from Western Australia. Only small quantities are exported from New South Wales and Northern Territory; but the shell from these States is of good quality. The exports from the several States during the three years prior to the war are shown in the following table:

States of final shipment.	1911. Quantity.	1911. Value.	1912. Quantity.	1912. Value.	1913. Quantity.	1913. Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Western Australia	1,374	240,764	2,708	421,609	1,521	274,724
Queensland	427	62,641	345	62,384	376	69,942
New South Wales	52	7,647	114	22,985	110	24,440
Northern Territory	64	14,166	64	16,113	58	13,616
Total	1,917	325,218	3,231	522,091	2,065	382,722

Most of the Australian pearl-shell is shipped to the United Kingdom, the only other important direct customer being the United States. The exports from the Commonwealth during the three years preceding the war are shown in the following table:

To	1911. Quantity.	1911. Value.	1912. Quantity.	1912. Value.	1913. Quantity.	1913. Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
United Kingdom	1,074	157,430	2,768	425,040	1,719	325,484
United States	760	166,143	373	95,155	235	51,371
Other countries	83	1,645	89	1,896	111	5,867
Total	1,917	325,218	3,230	522,091	2,065	382,722

On the outbreak of war the pearling industry in Australia was depressed, and there was a falling off in the

exports in 1914-15 to 1,313 tons, valued at £179,394, most of which, as in previous years, was sent to the United Kingdom. In 1915-16, however, the quantity exported increased, although the total value declined, the exports, including a small amount of shell not of Australian origin, being 2,506 tons, valued at £194,052.

NOTES

Flax-growing in Egypt.—Flax was at one time an important crop in Egypt, but owing to the establishment of the cotton industry on a commercial scale the area devoted to flax underwent great reduction. The areas planted in recent years were as follows: 1912–13, 1,652 acres; 1913–14, 940 acres; 1914–15, 899 acres; 1915–16, 1,472 acres. The increased attention given to the crop in 1915–16 was due to the high prices ruling in the English and French markets owing to the chief sources of supply having been cut off by the war. It is probable that a further extension will take place in the immediate future.

In *Bulletin No.* 12, *Technical and Scientific Service, Ministry of Agriculture, Egypt*, an account is given of an experiment in flax-growing which has been conducted at the Government Farm at Guemmeiza with the object of determining the amount of seed which yields the best results with reference both to seed (linseed) and to fibre (flax). The best fibre and the largest yield were obtained from the most thickly sown plots, but the amount of seed secured was smaller than in the less thickly sown plots. On some of the plots the stalks were gathered before the seed had been completely formed so as to obtain the best possible fibre whilst sacrificing the seed-crop; other plots were harvested at a later date in order to obtain both fibre and seed; and a third series was left still longer with the object of obtaining a good crop of seed. The seed obtained from the second and third series of plots was found to contain approximately the same percentage of oil; this is in harmony with the results obtained in England by Eyre and Fisher (see this BULLETIN, 1916, **14**, 115). The supposition that good flax can only be obtained by harvesting the crop before the seed is ripe was not supported by the results of this trial; the best return for the fibre crop per feddan was secured in the latest harvest. This experiment was carried out with Egyptian seed, but further trials are being made with seed from Ireland and from India.

A sample of flax straw produced in the course of the experiments conducted at Guemmeiza was received at the Imperial Institute in January 1917. It consisted of retted

flax stems of a dull greyish-yellow tint, measuring from 26 to 30 in. in length and from $\frac{1}{16}$ to $\frac{1}{8}$ in. in diameter.

By pressing and scraping the stems the shieve was easily removed, and a yield of about 24 per cent. of soft, fairly lustrous fibre, of a greyish-buff colour, was obtained. This fibre varied from 20 to 26 in. in length, most of it measuring about 24 in. The strength was irregular and on the whole not very good. The yield of 24 per cent. is only approximate, and is higher than would be obtained on a commercial scale, where some unavoidable waste takes place. Recorded yields of fibre from flax straw range from 14 to 27 per cent.

A firm of fibre merchants in London, to whom a sample of the straw was submitted, stated that the stalks were well grown and well retted, and that the fibre extracted by hand compared favourably with the best Irish and Belgian flaxes, and would be worth not less than £200 per ton in London under present conditions (January 1917).

The firm valued the retted flax straw in the condition of the sample at from about £10 to £12 per ton in the United Kingdom (January 1917). They considered, however, that owing to freight difficulties it was essential that the cleaning should be carried out at the present time in the country of origin, and added that it would be necessary to have this work superintended by trained European experts.

A firm of flax spinners in Belfast stated that they could not offer an accurate valuation for flax from a new source without treating some tons of the material, but they provisionally valued the extracted fibre at from £200 to £220 per ton delivered in Belfast (March 1917), adding that in normal times such flax would be worth rather less than £60 per ton. An expert flax scutcher who made a small-scale scutching trial for this firm with the straw stated that the straw was of promising appearance, but that on scutching the fibre was found to be poor, brittle and wasty.

The Production of Sandalwood Oil in Mysore.—The source of true sandalwood oil is the heart-wood of the trunk and larger roots of *Santalum album* Linn., a small evergreen tree native to Southern India, more particularly to Coorg and Mysore. It is estimated that about seven-tenths of the world's supply of sandalwood is derived from Mysore, in which State it is a Government monopoly, the extraction and exploitation of the wood being entrusted to the Forest Department.

The export trade in sandalwood before the war was in the hands of about half a dozen European firms, who acted as purchasing agents at the annual auction sales of sandalwood for the manufacturers of sandalwood oil in Europe and the United States. About 52 per cent. of the Indian export was sent to Germany for distillation;

about 18 per cent. went to the United States, and from 10 to 20 per cent. to the United Kingdom. The value of the total export of sandalwood from India in 1913–14 was £128,626; the share taken by Germany was valued at £56,303, the share of the United Kingdom at £28,326, and the share of the United States at £20,454.

In the two years that preceded the outbreak of war the price of sandalwood in Mysore had doubled, the Government having restricted the amount offered for sale to about 2,500 tons, the estimated amount of the world's annual consumption. This restriction of output was to some extent justified in view of the ravages of the disease known as "spike," which in recent years has caused the destruction of a large number of trees. The spike disease first became noticeable about the year 1900, and, although the Government has offered a reward to the discoverer of an effective remedy, no such remedy is at present forthcoming, and the precise nature of the disease is still unknown. The method adopted to control the disease consists in uprooting affected trees, and this is said to have checked its spread.

On the outbreak of war the market for sandalwood collapsed owing to the cessation of the demand from German buyers. This induced the Government to start the distillation of sandalwood oil in Mysore for export to Europe. The extraction of sandalwood oil by private persons in Mysore is not permitted, but the manufacture is carried on to some extent outside the State, especially in the South Canara district and at Kanauj in the Punjab. This oil is, however, not readily saleable in Europe owing to the defective methods employed in its preparation, and to its frequent adulteration with other oils. The production of sandalwood oil on the modern lines adopted by the Mysore Government is therefore a new industry in India. In the first instance a factory, estimated as capable of producing 2,000 lb. of oil a month, was erected near the Institute of Science, at Bangalore, and, owing to the success which attended the early working, it was enlarged and is now producing 5,000 lb. a month. A second factory is now being erected in Mysore, which will ultimately have an output of about 20,000 lb. of oil per month, or probably sufficient to supply the whole of the European demand for sandalwood oil. It is anticipated that the whole of the output of sandalwood from the South Indian forests will ultimately be dealt with at this factory.

The oil produced in the Government distillery has been found to meet the requirements of the British and other Pharmacopœias, and has been sold on the London market during 1916 at from 29s. to 50s. per lb. Each consignment is accompanied by a Government certificate guaranteeing its purity, and in this way it is hoped to maintain a high standard of quality. The sandalwood oil industry in the

United States is protected by an import duty of 20 per cent. on oil of foreign origin. It remains to be seen, therefore, whether Indian-distilled oil will be able to enter the United States market. Since the outbreak of war Messrs. Schimmel & Co., of Leipzig, are said to have established a distillery in Spain, and to be offering Spanish-distilled sandalwood oil at a cheaper rate than the Mysore producers, but from what source is not known.

The most common substitute for true sandalwood oil is the oil obtained from *Amyris balsamifera*, Linn., a Rutaceous plant native to Venezuela, and known commonly as West Indian sandalwood. Supplies of West Indian sandalwood are said to be diminishing, but oil from this source, mixed with other oils, and more or less approaching in physical properties the requirements of the British Pharmacopœia for genuine sandalwood oil, have come on the market from Germany from time to time.

There is a considerable demand for sandalwood in Eastern countries, particularly in India and China, for perfumery and ceremonial uses, and also for carving.

Owing to the high price of real sandalwood there is an import of substitutes into these countries chiefly from Australia.

The value and countries of origin of the "sandalwood" imported into India during recent years are shown in the following table:

From	1910–11.	1911–12.	1912–13.	1913–14.	1914–15.
	£	£	£	£	£
Western Australia	3,221	4,678	5,208	9,478	5,110
Straits Settlements	2,748	2,680	3,903	3,699	2,518
Other Countries	707	768	2,596	399	744
Total	6,576	8,126	11,707	13,576	8,372

The imports from the Straits Settlements shown in the above table comprise re-exports of sandalwood derived chiefly from Australia.

The quantities of "sandalwood" imported into China during the period 1910–14 and the countries whence the imports were derived are shown in the following table:

From	1910. Tons.	1911. Tons.	1912. Tons.	1913. Tons.	1914. Tons.
Hong Kong	6,092	5,815	3,716	4,753	4,823
Australia	338	602	1,564	—	2,217
Other Countries	364	167	3	240	271
Total	6,794	6,584	5,283	4,993	7,311

The imports into China from Hong Kong shown in the above table comprise re-exports of sandalwood derived in the first instance from Australia.

The so-called sandalwood exported from Australia is

mainly derived from *Fusanus spicatus* R. Br., a tree attaining about 30 ft. in height, native to Western Australia, whence the bulk of the export is derived.

The following table shows the value of the export of this wood from Western Australia during recent years :

1910.	1911.	1912.	1913.	1914.	1915.
£	£	£	£	£	£
70,775	85,596	27,533	47,589	65,919	83,556

In addition there is a small export from other States of the Commonwealth, chiefly of the South Australian sandalwood (*F. acuminatus* R. Br.), known locally as "quandong." The export of Australian sandalwood is chiefly to China, either direct or via Hong Kong, and to India either direct or via Singapore.

In the event of the whole of the annual output of genuine sandalwood in Southern India being utilised locally for the manufacture of oil, European distillers will be obliged to seek other sources of supply of raw material, and efforts will no doubt be made to cultivate *Santalum album* in other countries.

The wood is already being exported from the Celebes (Dutch East Indies), the quantity shipped from Macassar in 1911, 1912 and 1913, mainly to Holland, being 779, 453 and 392 tons respectively. It is said to be grown in Java, and has also been successfully cultivated in Mauritius, samples of oil prepared in the last-named country having been received for examination at the Imperial Institute in September 1913 (see this BULLETIN, 1914, **12**, 235). Owing to the semi-parasitic habit of the tree, the provision of suitable hosts may present some difficulty in new localities. In India some 144 different trees have been recorded as serving as hosts, of which 27 are leguminous species. As *S. album* is of slow growth, it requires to stand from 20 to 40 years to develop the maximum amount of fragrant wood, and it is therefore necessary to select as hosts species of trees that have a life of at least 40 years. Probably trees of the leguminous family would be the most suitable for the purpose, such trees as *Pongamia glabra*, Vent., and *Albizzia Lebbek*, Benth., commonly serving as host trees in India. In the matter of soil, *Santalum album* does not appear to be very exacting, but the highest yields of oil have been obtained from wood grown on poor rocky soils (see *Ind. For.*, 1915, **41**, 123).

South African Gum.—A sample of typical South African gum, probably derived from the "white thorn" (*Acacia horrida*), was examined recently at the Imperial Institute. The material consisted of small fragments of clear transparent gum, with one or two larger masses, varying from almost colourless to reddish-brown. Some pieces of leaf

and twig were present in the sample. The gum, which yielded a mucilage possessing good adhesive properties, was found on examination to contain 14·5 per cent. of moisture, 2·9 per cent. of ash, and 2·0 per cent. of matter insoluble in water. It had an acid number of 3·9, which is rather higher than that of good Sudan gums (1·2–2·4), while the relative viscosity of a 10-per-cent. solution at 22° C. was 8·0, which is lower than that of hard Kordofan gum (12·0).

Attempts have been made from time to time to find a market for South African gum in the United Kingdom, but these have been unsuccessful except at times when Sudan and Senegal gums have been scarce and dear. There appears to be no reason, however, why a market should not be found for this gum in South Africa for use in confectionery, pharmaceutical preparations, adhesives, etc. If a local market of this kind were established and the collection of the gum organised it might be feasible to start an export trade to the United Kingdom, as it would then be possible to ensure regular deliveries of the gum. Up to the present only occasional consignments have been placed on the British market, and, as the gum differs considerably from the better-known Sudan, Senegal and East Indian gums, it has not been possible to induce large manufacturers to take any interest in it owing to the uncertainty of supplies. As a rule, the occasional consignments which have been placed on this market have been difficult to sell and have realised low prices, compared with Sudan gum, viz. about 15*s.* per cwt., with Sudan gum at 18*s.* to 35*s.* per cwt. If regular supplies of South African gum of good colour and free from dirt could be placed on the market, it is probable that better prices than this could be obtained, though it is not likely that the gum would realise as high prices as good Sudan gum.

Chicory Substitute from South Africa.—The inhabitants of certain parts of South Africa, notably in the Waterberg and Zoutpansberg districts of the Transvaal, utilise the dried roots of the tree known as "witgatboom" (*Capparis albitrunca*, Burch.) as a substitute for chicory. In November 1916 a sample of the product was forwarded to the Imperial Institute in order to ascertain whether it would be of commercial value in the United Kingdom. It was submitted to a firm of chicory manufacturers in London, who stated that it was a very good substitute for chicory. They pointed out, however, that although it is permissible to mix chicory with coffee in the United Kingdom, provided the proportion of chicory present is duly stated on the packet, it is illegal to use any substitute for chicory for this purpose. In order to obtain a sale for the witgatboom preparation, therefore, it would be necessary to place it on the market under a special name, so that it could be sold on its own merits as

a substitute for coffee. The firm expressed a desire to proceed further in the matter, and they were, therefore, put in communication with the agent for the farmers in South Africa who collect and prepare the root. The tree is said to occur fairly plentifully in the above-mentioned districts of the Transvaal, and it is also widely distributed throughout Namaqualand to Griqualand West. The price of the root in South Africa is stated to be 20s. per 100 lb. (February 1917).

The Madras Fisheries.—Reference has been made in a previous number of this BULLETIN (1914, 12, 50) to the work of the Madras Government Fishery Department in connection with the production of sardine oil and guano, and an account was given of the results of examination at the Imperial Institute of specimens of these materials produced experimentally by the Department. In the present note reference will be made to the recent work of the Department on these and other matters, based on the Report of the Honorary Director for 1915–16 (G.O. No. 2764, 1916, *Revenue Dept., Govt. of Madras*).

The work of the Tanur Experimental Station, which is devoted to fish-curing and the manufacture of fish oil and guano, was almost at a standstill during the year owing to the almost complete absence of fish all along the coast. A new departure was made in pickling mackerel with salt and with vinegar and spices, but partly owing to the abnormal scarcity and consequent high price of the fish the experiments were not conclusive. In connection with these experiments an attempt was made to manufacture vinegar at the station. The results were fairly satisfactory, the product being twice the strength of local vinegar and the cost less than the latter. When the process has been improved it is hoped that it will be possible to produce vinegar at half the cost of British vinegar delivered at Madras in normal times. Only about $2\frac{1}{4}$ tons of fish guano and a proportionate amount of oil were made at the station, whilst the private factories, of which there are now nearly 250, were idle practically the whole season.

The operations at the Beypore cannery were likewise spoilt by the scarcity of fish. An experiment was made here in stoving the tins by means of solar heat. The tins were placed in a stout teak box, blackened inside, with a close-fitting, double-glass top, the whole being insulated by being placed in a case with double walls. A midday temperature of 240°–275° F. was readily attained by using the direct rays of the sun, and by means of a single mirror a temperature of 290° F. was reached. The stoving of the tins in this apparatus is stated to have been excellent.

The work of the piscicultural expert was devoted entirely to the fresh-water fisheries, and included the breeding

of both indigenous and exotic fish, the stocking of tanks, the introduction of fish for the destruction of mosquito larvæ, and the inspection of various rivers.

The Marine Biologist is concerned with the exploitation of the Government monopolies of the pearl and chank fisheries, the commercial development of marine industries, the economic improvement of the fishing population, educational work, and the investigation of the life-histories of food-fishes and their enemies and related subjects. Considerable progress is reported in the chank-fishing industry. Both the Tinnevelly and Ramnad fisheries have more than doubled in production, as compared with 1914–15, and the revenue derived from this source is rapidly increasing. Chank shells are largely used for making bangles in Madras, and, as the usual method of cutting by hand is laborious and comparatively costly, attempts were made in previous years to obtain a suitable power-saw, but without success. The question was referred to the Imperial Institute, and, as a result of enquiries made in this country, it was found that a type of machine-saw used for cutting Trochas shells was quite suitable for the purpose. A saw of this kind was sent to India for trial during the year. The Marine Biologist points out that if it proves successful—and there seems every reason to believe that it will—its introduction should greatly reduce the cost of production of shell-bangles, and thus enable manufacturers to pay a higher price for the raw material without entailing a rise in price of the finished product.

An important feature of the work of the Department is an experimental soap works, which is under the control of a trained chemist. In addition to ordinary and toilet soaps, fish-oil and fish-oil-rosin soaps for use as insecticides are made. The latter have been favourably reported on by the Government Entomologist, and are in considerable demand, enquiries having been received regarding them even from the Federated Malay States. New plant is being laid down and the scope of the work during 1916–17 is being extended to include glycerin recovery, and special attention is being paid to the possibility of utilising some of the lesser-known oils and fats and indigenous perfumes and colouring matters.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally.

AGRICULTURE

SOILS AND MANURES

Influence of Lime and Gypsum on the Availability of Potash in Soils.—It is generally stated that when lime or gypsum (calcium sulphate) is added to the soil the calcium replaces potassium in the insoluble potash-bearing minerals in the soil, with the formation of soluble potash salts which can be utilised by plants. During the present scarcity of potash manures farmers have been recommended to increase the amount of available potash in the soil by this means. In order to ascertain the effect of lime and gypsum in this connection, Briggs and Breazeale, of the Bureau of Plant Industry, U.S. Department of Agriculture, have conducted laboratory experiments with pegmatite and orthoclase (potash felspar), the types of the potash-bearing rocks and minerals that constitute the chief source of potassium in many of the citrus soils of Southern California (*Journ. Agric. Res.*, 1917, **8**, 22). They found that solutions of calcium hydroxide of different concentrations did not modify the solubility of the potassium in either pegmatite or orthoclase, whilst solutions of gypsum depressed the solubility of the potassium in orthoclase, the quantity of potash in solution decreasing progressively as the concentration of the gypsum increased. Similarly the addition of gypsum to a citrus soil which had been in cultivation for some time decreased the solubility of the potash. Experiments were conducted with wheat seedlings grown in solutions, and it was found that the potassium content of the seedlings was practically the same when the latter were grown in water containing finely ground orthoclase and in a saturated calcium sulphate solution containing the same quantity of orthoclase. Similar experiments in which a citrus soil was used instead of orthoclase showed a decreased absorption of potassium by wheat seedlings in the presence of calcium sulphate.

These experiments appear to indicate that the availability to plants of the potash in soils derived from orthoclase-bearing rocks is not increased by the addition of lime or gypsum. The results of experiments at Rothamsted, however, appear to show that lime does liberate potash in the soil, and Boussingault showed that the quantity of potash in the ash of clover is increased by

the addition of gypsum. It remains therefore to determine the effect of these substances on the other insoluble potash salts of the soil.

Green Manures.—C. M. Hutchinson, Imperial Agricultural Bacteriologist in India, has shown that the complete decomposition of a green crop depends on the incidence of the rainfall following its ploughing in (*Bulletin No.* 30, 1914, *Agric. Res. Inst., Pusa*). As the rainfall is frequently defective, it was suggested that the initial stages of decomposition should be carried out under artificial conditions, and it was found that the most complete breaking down and subsequent nitrification of the plant tissues were obtained by providing excess of moisture accompanied by anærobic conditions (i.e. lack of air) during the first stage, followed by a second one of less moisture and semi-anærobic conditions. A method for treating the crop under such conditions is described by Hutchinson in a subsequent *Bulletin* (No. 63, 1916). The green crop, as soon as it is cut, is placed in pits containing water for 24 to 48 hours. It is then removed, stacked in heaps and allowed to ferment, the rotted manure being applied to the land. To prevent the heaps from drying, their outsides may be plastered with clay, or the water remaining in the pit may be used for moistening them. Large quantities of ammonia pass into the water in the pits during fermentation, and, to prevent loss of this constituent, the smallest possible quantity of water should be used so that the whole of it may be used for moistening the heaps, whilst for the same reason the mud from the bottom of the pit may be stacked with the green manure in alternate layers. It was found that more complete fermentation could be obtained by inoculating the heaps with impure cultures of cellulose-destroying bacteria by making a water extract of fresh cowdung.

Experiments carried out at Pusa with oats have proved the marked superiority of fermented sunn hemp over the crop ploughed in green. It is suggested that where irrigation is practised the material should be allowed to remain in the fermenting pit, and the water, containing ammonia and other products of decomposition, run off on to the land at weekly intervals. It was found at Pusa that after 4 to 6 weeks, according to the temperature, the crop, whether sunn hemp, mustard, grass or maize stalks, had broken down to a fine material resembling well-rotted farmyard manure, and still contained a fair percentage of nitrogen which readily nitrified in soil. S. Milligan, the Imperial Agriculturist, points out in an Appendix to the *Bulletin* that the fermentation method is applicable not only to ordinary green manure crops, but might also be used for material such as sugar-cane stools, which have to be collected and burned before a succeeding crop can be grown.

Foodstuffs and Fodders

Cocoa.—Increasing attention is being given to cocoa-growing in Uganda (*Ann. Rep. Dept. Agric., Uganda*, 1915–16, p. 11). Only 159 acres of the plantations contain trees over five years old, but 4,113 are under five years, and 689 acres have been prepared for planting. The crop has a number of serious insect pests and diseases, but, provided that necessary precautions are taken, and suitable districts selected, the crop promises well. Planters are advised to adopt preventive measures against diseases, including Bordeaux mixture sprayed and painted on the trunks. With the latter method the solution is mixed with swamp clay to the consistency of a very thin paint and applied with a brush to the trunks and forks of the trees.

A large amount of cocoa has been planted in Sierra Leone during the last few years, and there are signs of an important industry in the near future (*Ann. Rep. Agric. Dept., Sierra Leone*, 1915, p. 6).

According to information received from the Colonial Office, the exports of cocoa from the Gold Coast during 1916 amounted to 72,127 tons, of value £3,846,091, as compared with 77,278 tons valued at £3,651,341 in 1915, and 52,888 tons valued at £2,193,749 in 1914.

Coffee.—In Uganda, coffee maintains its position as the principal crop on European plantations, and it is also a favourite with the natives as a crop for export (*Ann. Rep. Dept. Agric., Uganda*, 1915–16, pp. 10, 44). The area of European coffee plantations is 12,162 acres, and the estimated area planted in coffee by natives 8,464 acres. The exports in 1915 were £87,202 in value. Leaf disease (*Hemileia vastatrix*) is less prevalent owing to climatic conditions having been more favourable to the coffee, and cultivation and pruning being more systematically conducted. In the more humid parts of the Protectorate the life of the Arabian coffee tree is very short, so that *Coffea robusta*, which is indigenous, will probably be more widely cultivated as its yield is larger and more certain. In the drier and more elevated parts, Arabian coffee cultivation will gradually extend. The best new coffee-growing areas are on the foot-hills of Mount Elgon at altitudes of 4,360 to 5,000 ft.

According to the *Ann. Rep. Dept. Agric., Brit. E. Africa*, 1914–15, p. 95, coffee-leaf disease (*Hemileia vastatrix*) is not likely to become a serious menace to the coffee-planting industry in the East Africa Protectorate. Preventive and remedial measures must not be neglected, but the good soil and climatic conditions of those parts where coffee flourishes form a useful asset to the planter in controlling the pest.

Limes.—Data have now been accumulated which show that the lime tree will flourish and produce good crops of

fruit over a wide range of the East Africa Protectorate (*Ann. Rep. Dept. Agric., Brit. E. Africa*, 1914–15, p. 15). To complete the series of cultural experiments it remains to be ascertained by analysis the average acid content of the fruit. The more extended cultivation of the orange, lemon and grape-fruit, all of which thrive in the coffee districts, and the establishment of a lime industry are worthy of consideration in view of the need that coffee planters in the uplands should have a second cultivation to fall back upon in case of failure of the coffee crop, which is speculative even in the most favourable circumstances.

Sugar.—The Gunthorpes Central Sugar Factory in Antigua in 1916 made 13,372 tons of sugar (96° grey crystals) from 112,356 tons of cane, and the Basseterre Factory, St. Kitts, made 11,591 tons of sugar from 101,248 tons of cane. The recoveries are remarkably good and compare favourably with the results obtained in first-class factories in other parts of the world. Reckoned in terms of sucrose they show a recovery of 91·58 per cent. at the first-named factory and 91·39 per cent. at the latter (*Agric. News*, 1916, **15**, 356).

The work of the Agricultural Department of the Northern Provinces of Nigeria is influencing the cultivation of sugar cane in the Maigana district. Varieties of Pedigree cane from Barbados have been introduced and taken up by native cultivators, with whom they have proved extremely popular, being stouter in growth and containing a higher percentage of sucrose than the indigenous cane (*Rep. Agric. Dept., N. Provinces, Nigeria*, 1915, p. 2).

Interest is being taken in the East Africa Protectorate in sugar growing, and planters have imported canes from Natal for trial (*Ann. Rep. Dept. Agric., B.E.A.*, 1914–15, p. 15). In their suitability for sugar-growing the lower stretches of the Tana river valley far surpass any other part of the Protectorate, and it is computed that 241,000 acres of rich alluvial land are available there for cane cultivation.

Fodders.—A communication made recently to the French Academy of Agriculture referred to a case in which farm horses for 2½ years had been given as concentrated food a kilogram of barley per day with manioc (cassava) refuse which contains little nitrogen. The condition of the animals remained excellent. Manioc becoming scarce owing to the war, ground-nut cake, which is rich in nitrogenous matter, was substituted. The condition of the horses was in no way adversely affected by the change, and most of them ate the ground-nut cake with avidity. The possible use of ground-nut cake as food for horses is of special interest in France, whence a large proportion of the cake produced in the crushing of ground nuts has hitherto been exported to Germany, Scandinavia, etc., and used there for feeding cattle, especially milch cows.

In the manufacture of buttons and other small articles from vegetable ivory nuts (*Phytelephas macrocarpa*) there is a good deal of waste in the form of saw-dust, chips and turnings, which in some countries has been mixed with other ingredients in cattle food, but, as a rule, is wasted. A study of the chemical composition, digestibility, and feeding value of vegetable-ivory meal has been made at the Massachusetts Agricultural Experiment Station by C. L. Beals and J. B. Lindsey, and is the subject of a paper contributed to the *Journ. Agric. Research* (1916, 7, 301). Analyses showed the material to contain about 4 to 5 per cent. of protein and 75 per cent. of nitrogen-free extract. The quantities of fat and mineral matter are negligible, while crude fibre averages 7 per cent. The energy equivalent ranks well with that of other carbohydrate foods. Sheep ate the meal readily when it was mixed with other grains, and digested it thoroughly. Cows ate it when mixed with other feed without evidence of digestive disturbances, but refused it by itself. When fed as an addition to a basal ration the increase in milk was sufficient to indicate its positive value as a productive feed. The meal, however, does not fully equal maize meal for milk production.

Experiments conducted in Germany with vegetable ivory nuts (*Phytelephas* and *Hyphaene*) in the form of flour and chips, have also indicated that the material on the whole is readily digested by sheep and pigs (*Die Landwirtschaftlichen Versuchs-Stationen*, 1916, 88, 243; abstr. in *Internat. Rev. Sci. and Pract. of Agric.*, 1916, 7, 1131). Owing to its low percentage of protein, which too has a low digestibility coefficient, the meal could only be employed, if at all, in combination with other feeding stuffs rich in nitrogen, and, as the German report points out, its presence in concentrated foods such as oil-cakes must be regarded as an adulteration.

Oils and Oil Seeds

Coconuts.—In the Gold Coast a good proportion of the five-year-old trees at Assuantsi have borne fruit, and the plot is most promising (*Rep. Agric. Dept., Gold Coast*, 1915). Future success is dependent on the control of the rhinoceros beetle, which is the chief pest. Catching the beetles by hand is expensive but effective, over 4,000 adult beetles having been destroyed during 1915 in this way, and no trees were killed by this pest. The exports of copra in 1915 amounted to 770 tons, 114 tons more than in the previous year. Attempts to popularise the crop by free distribution of nuts to native chiefs and the establishment of nurseries have not met with much response.

Coconut trees already growing in certain districts of Sierra Leone show that larger areas on the southern shore and on the Bullom shore are suitable for coconut cultiva-

tion. In order to encourage the planting of the palm the Government have sanctioned a scheme for the sale of Ceylon seed nuts at a reduced rate to the natives, and a bonus will be given for each healthy tree after about four years, or the nuts will be distributed free of charge without a bonus (*Ann. Rep. Agric. Dept., Sierra Leone*, 1915, p. 4).

Storms in Jamaica caused some damage to coconut palms during 1915-16, but the actual loss of palms was small, and trade in coconuts was profitable (*Report on Jamaica*, 1915-16, *Col. Rep. Ann. Series, No.* 909 [Cd. 8172-35], 1916, p. 12). During the year 600 tons of copra were exported, and the industry seems likely to increase.

Experiments on the effect of manures on coconut trees in bearing have been in progress on a plantation in Porto Rico since 1912 (*Rep. Porto Rico Expt. Sta.*, 1915, p. 25). The application of manures had but little effect on the yield of nuts during the first two years, but marked gains have been recorded during 1915 from trees receiving a complete manure, *i.e.* one containing 6 per cent. of nitrogen, 8 per cent. of phosphoric acid and 12 per cent. of potash. Using 10 lb. of this manure per tree, a gain of 30 per cent. in the yield of nuts per tree was obtained, and with 20 lb. per tree a gain of nearly 60 per cent. above that from the unmanured control plot. Where nitrogen or potash was omitted the yield was not increased, and when phosphate was omitted only a slightly increased yield was obtained. Records of the individual yields from 350 trees showed that many were unprofitable and should be replaced by young trees; planters are therefore recommended to investigate the production of individual palms with a view to replacing those giving poor yields.

Experiments in Ceylon have shown that old trees (50 years and over), of which there is a very large number on small native plantations, are improved in yield and vigour by manuring and cultivation (*Rep. Dept. Agric., Ceylon*, 1915, p. 2). The yields obtained were as follows: 1911—26·7; 1914—42·1; 1915—42·7 nuts per tree, representing an increase of 60 per cent.; no manure was applied in 1915. The use of a complete manure at a cost of 33*s.* 4*d.* per acre raised the yield from 29 nuts per tree to 57 (96 per cent.), whilst the application of a soluble mixture every six months at about the same cost raised the average yield per tree from 23·4 nuts to 54 (131 per cent.). Mulching with sensitive plant (*Mimosa pudica*) and other weeds together with a mixture of basic slag and kainit in equal parts at the rate of 400 lb. per acre raised the yield from 30·7 nuts per tree in 1911 to 56 per tree in 1915 at a cost of only 14*s.* 8*d.* per acre. Manuring increases the power of the trees to retain young nuts, so that a larger proportion matures.

From analyses of a number of manures commonly used on coconut plantations in Ceylon, and of the soils of these

plantations, it appears that the manures employed contain large amounts of phosphoric acid, and that the response of the trees to the application of manures is due largely to phosphoric acid, in which constituent Ceylon soils are deficient, while the ratio of phosphoric acid to nitrogen (100 : 235) is also low (*Tropical Agriculturist*, 1916, **47**, 137).

Ground Nuts.—Experiments were continued in Montserrat on small plots in 1915–16, the following yields of cured nuts calculated per acre being obtained: Virginia running, 2,246 lb.; Virginia bunch, 2,170; Rufisque, 1,680; Gambia, 1,339. The yield from the last-named variety has varied in seven years from 724 to 2,041 lb. per acre with an average of 1,479 lb. In the present case the yield is disappointing as the season was satisfactory (*Rep. Agric. Dept., Montserrat*, 1915–16, p. 14). The Virginia running variety gave an average yield over four years of 1,825 lb. of cured nuts per acre; when planted one plant to a hole 1,815 lb. of nuts per acre were obtained, whilst with two plants to a hole the yield was 2,677 lb.

Further experiments in Montserrat on the control of leaf rust (*Uredo* sp.) tended to confirm previous results and showed that spraying with Bordeaux mixture was useful for the control of this disease (*loc. cit.* p. 24). Caterpillars of the woolly pyrol moth (*Thermesia gemmatalis*) were killed by dusting the plants with a mixture of lead arsenate and lime in the proportion of 1 to 6 (*loc. cit.* p. 15).

Soy Beans.—Experiments at the Moumahaki Farm, New Zealand, with nine varieties of soy beans obtained from America showed yields of seed varying from 14 to 45 bushels (60 lb.) per acre. The best result was obtained from the "Auburn" variety, while the "Ito-San" variety also gave a good yield, viz.: 38 bushels per acre (*Journ. Agric., New Zealand*, 1916, **13**, 140). The "Auburn" variety also gave a high yield of forage 13·14 tons per acre, which was equalled by "Sable" and only surpassed by "Early brown," which gave 14·28 tons per acre. The last-named variety, however, yielded only 27 bushels of seed per acre. The soil on which the plants were grown was manured but not inoculated, and nodules did not form on the roots.

Miscellaneous.—According to Heim the seeds of *Sterculia foetida* yield an oil which on heating alone or with sulphur or sulphur chloride is converted into a gelatinous elastic mass similar to that produced on a commercial scale from other vegetable oils and sold as "factice" for use in rubber compounding. It is stated that the oil could be produced in large quantities in Indo-China (*Bulletin de l'Off. Colon.*, 1916, **9**, 348).

Several new and interesting Brazilian oil seeds, and the oils derived from them, are dealt with by Bolton and Hewer in a recent number of the *Analyst* (1917, **42**, 35). The more

important seeds are those derived from various species of palms. The "Caiaué" palm, according to the authors, is *Elaeis guineensis*, but it is generally regarded as *E. melanococca*. The fruit of this palm, like that of the African oil palm, contains oil in the pericarp and also in the kernels; these oils are suitable for the same purposes to which African palm oil and palm-kernel oils are put, but differ slightly, though distinctly, from the oils derived from African oil-palm fruits. Other palm-kernels examined were those of *Astrocaryum* spp., *Acrocomia sclerocarpa*, *Maximiliana regia*, *Cocos Syagrus*, *Attalea funifera* and *Oenocarpus Batava*. With the exception of the last species, the kernels of which only contained traces of oil, the kernels in all cases yielded oil suitable for edible purposes. The results of examination at the Imperial Institute of several of these oil seeds are referred to in this BULLETIN (p. 38).

Results of the examination of several little-known oil seeds indigenous to, or growing in, Japan and the adjacent islands have been published by Uchida (*Journ. Soc. Chem. Indust.*, 1916, **35**, 1089). Among these may be mentioned "Shiromoji" seed (*Lindera triloba*, Blume), "Kuromoji" seed (*L. sericea*, Blume) and "Aburachan" seed (*L. praecox*, Blume), the kernels of which yielded on pressing about 45, 58 and 18 per cent. of oil respectively. The oils of the first two species are said to be suitable for soap manufacture.

The kernels of *Hernandia peltata*, Meissn., yielded about 34 per cent. of oil suitable for the manufacture of soaps, boiled oil, rubber substitute, or for illuminating purposes. Kernels of *Styrax Obassia*, S. and Z. ("Hakuunboku" seed) yielded 30·5 per cent. of oil. The flesh and kernels of the fruit of *Magnolia hypoleuca*, S. and Z., are both rich in oil, but the kernels are difficult to separate from the seed coat, and are unlikely therefore to prove important in commerce; on pressing the whole fruit a yield of 31·5 per cent. of dark brown oil was obtained suitable for burning or for soap manufacture. The author includes the results of chemical examination of the oils, together with information on the nature of the oils and methods of purification and decolorisation.

An interesting series of articles dealing with the production and industrial employment of vegetable oils is now appearing in the *Engineer*. The articles are illustrated by drawings and reproductions of photographs of modern oil-mill machinery, and deal fully with the equipment of oil mills and the special machinery used for different oil seeds.

RUBBER

Hevea.—Interesting information on the yield of rubber from Hevea trees and the cost of production in Uganda is contained in a paper read by E. Brown at a Conference

of the Uganda Planters' Association. Tapping experiments at Kivuvu were commenced in 1914 with 6,000 trees, and were gradually extended until 12,000 were tapped in 1916. The average yields per tree from all trees, including small trees, were as follows: 1914, 8 oz.; 1915, 11½ oz.; 1916, 22¼ oz. The yields from the oldest trees have not been recorded separately, but the author considers that these would have yielded 3 lb. per tree. This estimate corresponds with the results obtained in experiments conducted at the Botanic Gardens, Entebbe, where 611 trees, varying in age from 7 to 11 years, were tapped for 10 months on alternate days by the V-system, and yielded an average of 2·90 lb. of dry-smoked rubber per tree (*Rep. Bot., For. and Sci. Dept., Uganda*, 1915–16, p. 4). The area of trees tapped at Kivuvu in 1916 was 120 acres, and the total yield of rubber was 16,700 lb. According to the author the cost of production, including freight and selling charges, fell from 1*s.* 0½*d.* per lb. in 1914 to 10*d.* per lb. in 1915 and 9*d.* per lb. in 1916. An area planted in 1911 with plants one year old from seed reached a tappable size early in 1916, and during that year yielded 6¼ oz. of rubber per tree.

According to the *Ann. Rep., Dept. Agric., Uganda*, 1915–16, p. 11, there were in the Protectorate at the end of March 1916, 1,072 acres of rubber trees over five years old and 328 acres under that age, in addition to 4,509 acres over two years old interplanted with coffee, and 238 acres under two years old, making a total of 6,147 acres. Natives are growing 1,062 acres of Hevea, as well as 2,273 acres of Ceara rubber, and Missions 169 acres of Hevea and 121 acres of other rubbers. The quantity of rubber exported during the year amounted to 52,349 lb., compared with 22,056 lb. in the previous year. Only a small area has reached the tapping stage, and small shipments from plantations have fetched good prices. So far the results are encouraging, and the trees do not suffer much from pests or diseases.

In certain districts of the East and West Provinces of the Gold Coast natives are giving increased attention to the cultivation of Hevea, and nurseries for the distribution of stumps have been established by the Agricultural Department (*Rep. Dept. Agric., Gold Coast*, 1915). In 1915 53,305 plants and 349,450 seeds were distributed from the Agricultural Stations. Nearly one-third of the plants were distributed in the Peki district. On one of the European rubber estates a yield of nearly 20,000 lb. of rubber was obtained in 1915 from about 75 acres, equivalent to 2 lb. per tree, compared with 1¼ lb. in the previous year. On an estate at Dunkwa, in Ashanti, 75 per cent. of the trees planted in 1911 attained a tappable size in 1915. At Axim 150 acres of 7- to 10-year-old trees yielded, as a result of

nine months' tapping, 27,402 lb. of rubber—that is, 1·68 lb. of rubber per tree, or 184 lb. per acre—at an average cost of 11·68*d.* per lb., f.o.b. Axim.

The results of Hevea tapping experiments carried out at Peradeniya during 1915 are given by Petch in *Bulletin No.* 25, 1916, *Dept. Agric., Ceylon.* These experiments were commenced in 1912, with the object of determining the differences in yield and the effect on the trees of systems of tapping varying in the time between successive tappings or in the spacing of the incisions. They are dealt with in two series. In the first series the object is to ascertain what difference, if any, exists between the yield, etc., obtained by tapping regularly on alternate days and tapping daily during alternate months; in the second series, also, the effect of different time intervals on the yield is being investigated, especially with a view to determining the value of weekly tappings, and, in addition, different methods of spacing the cuts on one-third the circumference are being tried. The results obtained during 1912–13 and 1914 have been published previously by the Department of Agriculture, Ceylon, in *Bulletins Nos.* 12 and 17 respectively. The experiments are being continued, and no definite conclusions have yet been arrived at.

In the preceding number of this BULLETIN (1916, **14**, 632) reference was made to the plantation industry in Cochin China, and it was stated that on January 1, 1916, 173,000 acres were under rubber in that country and in the adjacent countries of Annam and Cambodia. This area is the total of the rubber estates; the area actually planted with rubber on that date was about 42,000 acres, the number of trees planted amounting to 5,000,000 (*India Rubber World*, 1916, **54**, 650).

It is known that the growth and yield of Hevea are poor at high altitudes. Spring has shown that seed production is also affected adversely (*Agric. Bulletin, F.M.S.*, 1916, **5**, 3). There was a slight reduction in the quantity of seed produced at 1,000 ft.; at 1,800 ft. only a few seeds were formed; and at 2,400 ft. none at all. Further experiments are being made with a view to ascertaining the cause of non-production of seed at the higher elevations.

According to Whitby (*India Rubber Journal*, 1913, **45**, 941) the natural coagulation of Hevea latex on standing is due to the presence of an enzyme. Campbell has investigated this point recently, and has published results (*Journ. Soc. Chem. Indust.*, 1917, **36**, 274) which support Whitby's statement.

From the results of a brief investigation (*Journ. Soc. Chem. Indust.*, 1916, **35**, 1046) on the variability of plantation Para rubber with different technical mixings, Eaton and Grantham conclude that such mixings containing fillers and accelerators exhibit variability in time of cure, but to

a less extent than mixings containing only rubber and sulphur, such as are used frequently for the purpose of testing the quality of rubber. A mixing containing only rubber and sulphur is therefore particularly suitable for determining the time of cure in plantation Para rubber.

Funtumia.—Tapping of trees at Aburi for the third year showed a marked decrease in yield of rubber (*Rept. Agric. Dept., Gold Coast*, 1915, p. 11). The yields of dry rubber per acre were as follows: first year, 49·75 lb.; second year, 22·5 lb.; third year, 15·98 lb.

General.—There are at present over 2,000 acres under rubber in Trinidad and Tobago, but the exports are small, only 5,031 lb. being exported in 1915. A committee of the local Board of Agriculture has been appointed, and a Rubber Survey initiated with a view to enquiring into the conditions of rubber trees planted in these islands and to decide upon the best methods of working (*Bulletin Dept. Agric., Trinidad and Tobago*, 1916, **15**, 149).

Fibres

Flax.—In the *Ann. Rep. Dept. Agric., B. E. Africa*, 1914-15, an account is given by the Government Flax Expert of the progress of the flax industry in the Protectorate. Certain experiments are described, and reference is made to a consignment of flax, grown at Kabete, which was submitted to London flax merchants and favourably reported on. It is considered that even better flax can be produced at certain places in the Highlands. At Lumbwa, for example, where a flax factory has been established by the Highland Flax and Fibre Syndicate, the fibre is certainly superior to most of that obtained at Kabete. The whole of the flax produced in the Highlands is dew-retted. If machinery can be obtained the industry will undergo rapid development. Some hundreds of acres are being planted at Lumbwa, and another factory is to be erected there. It is expected that eight more factories will be established in various districts as soon as machinery can be secured. Planters are advised to adopt a co-operative system, as the larger the factory the greater would be the profit per acre.

Posidonia australis.—An account of the remarkable deposit of this marine fibre on the foreshore of parts of South Australia has already been given in this Bulletin (1907, **5**, 298). A report on the available supplies of this material and the cost of raising it has been given by D. C. Winterbottom on pp. 49-52 of *Bulletin No. 1, 1916, Dept. Chem., South Australia.* All the work done hitherto on marine fibre has been carried out on leases in Spencer's Gulf, between Tickera and Port Jarrold. Leases are also held in St. Vincent's Gulf but have not yet been exploited. It

is estimated that there is an area of about 120 square miles of workable deposit in each of these localities, and that the total quantity of fibre recoverable would be about 4,600,000 tons. There are two undertakings at present at work, viz. the Posidonia Fibres Syndicate at Port Broughton and the Anglo-Foreign Fibre Co. at Port Pirie. With the plant now in use these two companies could not produce more than 22-26 tons of dry fibre per week and could not sell it profitably at less than £17 per ton at Port Broughton or Port Pirie. An estimate is given of the cost of raising and washing the fibre.

A more detailed account of Posidonia fibre is given by D. C. Winterbottom in "Marine Fibre," which has been issued as *Bulletin No. 4, 1917, Dept. Chem., South Australia.* The Posidonia plant is described, the development of the marine fibre industry is reviewed, and particulars are recorded of the operations of the various companies who have been engaged in raising the fibre and preparing it for the market. The methods employed by the different companies are compared, the properties of the fibre are described, and particulars are given as to the cost of production and the possible ways in which the material could be utilised. Although the fibre can be used for the manufacture of textiles, the materials made from it are somewhat weak, brittle, and harsh to the touch, and its value for this purpose is therefore rather low. It is suggested that if a method of toughening and softening the fibre could be devised, the success of the industry would be assured. A quantity of Posidonia fibre has been used locally as an insulating material for steam and refrigerating plants; but the available market in Australia is comparatively small, and the exportation of the fibre to other countries for this purpose is not likely to be remunerative.

Kapok.—The use of kapok and its substitutes has undergone considerable expansion during the present war, particularly as a filling material for lifebelts and waistcoats and other forms of life-saving appliances. In view of the utilisation of kapok and other flosses for this purpose, an investigation has been carried out by Messrs. C. F. Cross and E. J. Bevan with the object of devising a rapid method for determining the approximate value of representative samples, and the results have been published in *Journ. Soc. Dyers* (1916, **32**, 274).

It has usually been assumed that the impermeability of the material to water is due to the presence of such constituents as oil, wax and resin in the wall of the fibre; but it has now been found that this is not the case. The amounts of such constituents vary considerably in different samples, but the variations do not show any correlation with the resistance of the fibre to the admission of water,

and the resistance is not appreciably affected by the removal of these substances.

Three tests are recommended for the rapid determination of quality in the laboratory. The first of these is observation of the degree of lignification of the fibre by the phloroglucinol test; the best samples do not give any reaction with phloroglucinol, but the lower qualities give a reddish-brown or even a magenta-red coloration, typical of lignocelluloses. The second test consists in the microscopical measurement of the diameters of the fibres; the more uniform the diameter, the higher is the quality of the material. The third test is carried out by floating the fibre on the surface of aqueous alcohol, of sp. gr. 0·928, and determining the relative rates of wetting and sinking of the different samples.

Particulars are given of the flotation and resistance to submersion of certain appliances made with kapok. The life-saving jacket tested contained 700 grams of kapok, and, since the average floating power of the compressed fibre is equal to 15 times its weight, the jacket, when submerged, exerts a lifting power of 10·5 kilograms. When placed in water and partially submerged by a weight of 9 kilos. the jacket still supported an extra load of 1·3 kilos. after 72 hours; after 100 hours it still required an addition of 1·0 kilo. to submerge it, and after 192 hours the weight required was 0·9 kilo.

Paper-making Materials.—In South Australia the difficulties experienced in obtaining certain kinds of paper owing to the war have emphasised the fact that the State is entirely dependent on external sources for its supplies of paper and millboard. An investigation has, therefore, been made of the possibility of establishing a paper-making industry in South Australia, and a report on the subject by W. A. Hargreaves, M.A., B.Sc., Director of the Department of Chemistry, has been published as *Bulletin No.* 1 (1916), *Dept. Chem., S. Australia.*

After considering the various raw materials in the country which could be used for paper-making, it is shown that the principal material is cereal straw, large quantities of which are now regarded as useless and are burned by the farmers. It is estimated that more than half a million tons of straw are available per annum, and it is shown that if a large quantity of this were employed and if a substitute for wood-pulp could be produced locally, the State should be able to compete with other countries in the production of good paper. When caustic soda and sodium sulphate are produced from the large deposits of salt in South Australia, the prospects of a paper-making industry will be still more favourable. Estimates are given of the capital required for the establishment of a paper mill and of the costs of manufacture.

In an appendix to this *Bulletin*, a preliminary report is given by J. C. Earl, A.I.C. (formerly of the Scientific and Technical Research Department of the Imperial Institute), on the value of several South Australian raw materials for paper-making. The following products have been investigated: (1) The leaves of *Xanthorrhoea semiplana*. These require somewhat drastic treatment for the production of a satisfactory pulp, and it does not seem probable that they could be profitably employed for paper-making. (2) The fibre of *Posidonia australis*. This fibre cannot be pulped satisfactorily by caustic soda, but it can be suitably reduced by chlorine. The economic production of pulp from this material demands cheap chlorine and large supplies of the washed fibre at £4 per ton, conditions which at present cannot be realised. (3) The complete plant of stinkwort. This shows some possibility for use as a paper-making material, but gives only a low yield of pulp. (4) The inner trunk of the grass-tree or yacca (*Xanthorrhoea Tateana*). If obtainable cheaply and in sufficient quantity, this material might prove of service. (5) Straw. Preliminary experiments have shown that the South Australian straws will yield satisfactory paper-pulp, that the treatment required is not so severe as that usually recommended for straw, and that the straw pulp can be used alone for the manufacture of papers of ordinary qualities. (6) Marram grass (cf. this Bulletin, 1913, 11, 164). This material could be employed alone for special qualities of paper and might also find extensive application in admixture with straw. (7) *Lepidosperma gladiatum*. This grass gives a good yield of pulp which is somewhat difficult to bleach but furnishes an excellent, strong paper; its utilisation is well worth consideration.

An investigation of the native woods of Tasmania has been carried out on behalf of the Tasmanian Government by Henry E. Surface, Consulting Engineer in Forest Products, Madison, Wisconsin, U.S.A., and his report has been issued as a Parliamentary Paper (1915, No. 8) entitled, "Feasibility of Manufacturing Paper Pulp from Tasmanian Timbers." The following timbers were examined: myrtle (or beech), *Fagus cunninghami*, Hook.; swamp-gum, *Eucalyptus regnans*, F. v. M.; blue gum, *Eucalyptus globulus*, Labill.; and stringy-bark, *Eucalyptus obliqua*, L'Her. All these are hard woods with very short and slender fibres; the average length of the fibres is about 1 mm. (or 0·04 in.). These timbers are not suitable for conversion into either mechanical or sulphite pulp, but when treated by the soda process they give an excellent pulp, which, when bleached, is well adapted for use in the manufacture of book, magazine, or writing papers. The yield of pulp, however, is comparatively small and unusually large quantities of chemicals and fuel are required for its manufacture. The results

indicate that the utilisation of these woods in Tasmania for paper-making would not be profitable under the present or even normal conditions. The pulp of stringy-bark wood could be produced at a lower cost than that of any of the others, but its manufacture could only be remunerative under exceptionally favourable circumstances. The conclusion is reached that the question of the utilisation of these four woods or of woods of similar character is not worth further consideration unless very radical changes should take place in forest-logging, manufacturing, market, tariff, and other related conditions.

Cotton

Egypt.—The series of publications being issued by the Ministry of Agriculture on *Egyptian Agricultural Products* has recently been augmented by the appearance of No. 3A, which deals with cotton. This number, prepared by Mr. Gerald C. Dudgeon, gives an account of the history, development, and botanical relationships of Egyptian cottons. The information afforded with reference to the origin and establishment of the various commercial varieties of Egyptian cotton is of special interest. Tables are appended showing the areas, yields, prices and distribution of the different varieties.

Two further numbers of the series are to be devoted to the subject of cotton, one dealing with the cultivation of the plant in modern times, and the other with the marketing of the crop and the industrial uses of Egyptian staples.

Uganda.—In the *Ann. Rep. Dept. Agric., Uganda Protectorate, for the year ended March* 31, 1916, an account is given of the position of the Uganda cotton industry. Owing to the fact that for six months of the 1914–15 season cotton was almost unsaleable (see this BULLETIN, 1916, **14**, 132) and the crop remained long unginned, seed for sowing was not obtainable for a considerable period, and consequently the area planted in 1915–16 was much less than in the previous season and much of the seed was sown too late to produce an average yield. The following are the approximate areas planted in recent years: 1911–12, 60,920 acres; 1912–13, 50,100 acres; 1913–14, 110,264 acres; 1914–15, 118,778 acres; 1915–16, 92,127 acres. The exports in 1915–16 were 91,231 cwts. of ginned cotton and 8,110 cwts. of seed-cotton, of total value £245,426, whilst in 1914–15 they amounted to 107,139 cwts. of ginned cotton and 30,188 cwts. of seed-cotton, of total value £351,146. Most of the cotton is consigned to the United Kingdom, but last year about 9,000 cwts. went to India. Bombay spinners have expressed their appreciation of the staple and it is probable that India will become a regular customer. Uganda cotton, when in good, clean condition, is of a high standard and realises 1·2*d.*–1·3*d.*

per lb. in advance of "middling" American. The reputation of the cotton, however, has been somewhat injured by a large part of the exports consisting of stained and weather-beaten fibre. Samples of the cotton of the 1915-16 crop were submitted to spinning tests by Mr. J. W. McConnel of the Fine Cotton Spinners' and Doublers' Association, Manchester, who reported that "the cotton is very inferior to ordinary Egyptian, but compares favourably with extra-stapled American." This is regarded as very satisfactory, as the Department of Agriculture are aiming at the production of the latter kind, and have accordingly carried out selection experiments during four seasons with two long-stapled American Upland varieties, viz. Sunflower and Allen, both of which have proved well suited to the country.

Nigeria.—In the *Rep. Agric. Dept., Northern Provinces, Nigeria*, 1915, reference is made to experiments carried out in the Maigana Plantation with the following varieties of cotton: Nyasaland, Allen, Cambodia, Georgia and Gwundi (a native kind). Cambodia has not proved satisfactory. Gwundi gives good yields, but does not realise a sufficiently high price to enable it to compete with the American varieties. The Allen and Nyasaland varieties maintained their average yield in 1915 and the strength of the fibre showed an improvement on that of the previous year's crop. The Georgia cotton gave excellent yields.

The *Ann. Rep. Agric. Dept., Southern Provinces, Nigeria*, 1915, gives a record of experiments conducted at the Experiment Station at Ibadan. The results of trials continued through the years 1910-14 showed that Georgia and Upland varieties were the most satisfactory, and seed of these two kinds was therefore planted during 1915. The Georgia cotton yielded 135·40 lb. per acre of value 8·18*d.* per lb. (with "middling" American at 7·66*d.* per lb), and the Upland cotton 132·25 lb. per acre of value of 8·13*d.* per lb. Efforts are being directed to the improvement of the Georgia variety by selection. Sufficient specially selected seed was obtained to plant 10 acres in 1916. Arrangements have been made with farmers in the Oyo district to plant Georgia cotton and keep it free from other varieties, so as to provide a large quantity of pure seed for distribution in 1917. The British Cotton Growing Association have offered an extra ¼*d.* per lb. for seed-cotton of this type and, in order to encourage the farmers, have promised to pay a further ¼*d.* per lb. as bonus.

Montserrat.—An account of the position of the cotton industry in Montserrat is given in the *Rep. Agric. Dept., Montserrat*, 1915-16. The area planted during that year was 1,953 acres and the yield amounted to 279,595 lb., or an average of 143 lb. of lint per acre. In some districts the cotton plants suffered from severe and persistent attacks of

the cotton worm. This pest, however, is being controlled to some extent by the continued increase of the wasps, known as "Jack Spaniards" (*Polistes annularis*), which were introduced from St. Vincent for the purpose. Experiments have been continued with a view to effecting improvement of the cotton now grown in the island. Particularly good results have been obtained with a strain known as the Douglass' type, and an effort is being made to perpetuate this form by the cultivation of selected plants.

United States.—In certain parts of the United States the cotton crop is sometimes seriously damaged by the common red spider (*Tetranychus bimaculatus*, Harvey), one of the spinning mites. A useful account of this pest, including its distribution, habits, life-history, and the methods of control, has been published recently as *Bulletin No.* 416, 1917, *U. S. Dept. Agric.*

Although the red spider occurs in all parts of the United States, its activity as a cotton pest has hitherto been confined to that part of the cotton belt which comprises North Carolina, South Carolina, Georgia, Florida, Alabama and Mississippi. It has been estimated that during a season in which red spider attack is particularly severe the planters of this region suffer a loss of about $2,000,000 (£417,000).

The red spider infests many and various species of plants, both wild and cultivated. Some of these host-plants support the pest during the cold period of the year and others during the spring and summer months. In Colorado the red spider is known as a pest of fruit trees, and in central California as a pest of hop fields.

When cotton plants are attacked severely by the red spider, their vitality is decreased and shedding of leaves and bolls results; in extreme cases the plants are completely defoliated and subsequently the stalk dies. Control of the pest is best achieved by the adoption of clean methods of cultivation, all weeds and other plants which harbour the mite being destroyed. Spraying with contact insecticides is effective provided that every leaf on an infested plant is moistened by the spray, and that a second spraying is carried out in order to kill the individuals which were eggs at the time of the first spraying.

FORESTRY AND FOREST PRODUCTS

New Zealand Forestry.—The clearing of bush land in New Zealand to make way for settlement has resulted in large areas of mountain land being denuded of forest, and valuable timber trees, such as the kauri pine, are approaching extinction. With a view to educating public opinion as to the necessity for a properly organised forestry programme a New Zealand Forestry League has been formed. At the inaugural meeting of the League held in July 1916, Mr. D. E.

Hutchins, who is preparing a comprehensive report for the Government on the forests and forestry of the Dominion, delivered an address in which he discussed the various aspects of State forestry (*Journ. of Agric., New Zealand*, 1916, **13**, 295, 375). It has been thought that the forest trees of New Zealand grow too slowly to be economically preserved, and that their place should be taken by forest plantations of exotic timbers, and by imported timber. Owing to the absence of scientific forestry and trained foresters in New Zealand the actual production of timber per acre per year in the forest has never been measured, but Hutchins considers that the indications are fairly clear that the native New Zealand timber trees grow, on the average, decidedly faster than the five chief timber trees of Europe. The quality of the native timbers compares favourably with that of the timbers of Europe and North America, and the one real fault of the New Zealand forests as they exist to-day is the low "stand" of timber. This can, however, be improved by good forestry, and Hutchins considers that instead of proceeding with the formation of forest plantations the existing forests should be preserved. He advocates the formation of a separate Forest Department, and that forest demarcation be proceeded with immediately, followed after the war by a forest loan and forest development. He considers that the cost of artificial plantations would be more than New Zealand, with all its natural wealth, could afford, and points out that experience in South Africa, where the forests have been dealt with scientifically for the past thirty-three years, shows that native forests can be worked and preserved.

The Damping-off of Coniferous Seedlings.—The disease known as "damping-off" frequently causes heavy losses in nurseries, and, although the usual methods of prevention—viz. good drainage and aëration of the seed-beds, and using as little water and shade as possible—are satisfactory in many cases, they are not sufficient if the fungoid parasites which cause the disease are present in large quantities. Experiments on disinfection of the soil to control the disease in nurseries of coniferous seedlings have been conducted by the United States Forest Service, and the results recorded in *Bulletin No.* 45, 1917, *U.S. Dept. Agric.* No one method can yet be recommended, as the results in different soils and localities varied somewhat, and it is suggested that small-scale trials of various disinfectants should be made in order to determine the method best suited to the local conditions. The treatments suggested, all of which have proved satisfactory in one or more places, are as follows for heavy soils: (1) Sulphuric acid (S.G. 1·82), $\frac{3}{16}$ or $\frac{1}{4}$ fluid oz. per sq. ft.; (2) copper sulphate, $\frac{1}{8}$ or $\frac{3}{16}$ oz. per sq. ft.; (3) zinc chloride, $\frac{1}{2}$ oz. per sq. ft.; in each of these cases the dis-

infectant should be dissolved in 1 or 2 pints of water according as the soil is wet or dry, and applied immediately after the seed is sown and covered; (4) formaldehyde (40 per cent. solution), ½ fluid oz. dissolved in 1 or 2 pints of water and either applied 10 days before the seed is sown, keeping the bed covered with paper or tarpaulin for that period, or applied 3 days before seed-sowing and not covering the beds; (5) air-slaked lime, ¼ or ½ oz. per sq. ft., applied dry and raked into the upper 3 in. of soil just before sowing, followed by $\frac{3}{16}$ oz. sulphuric acid (S.G. 1·82) dissolved in 1 or 2 pints of water immediately after the seed is sown and covered. For sandy soils slightly smaller quantities of the disinfectant are recommended, and 1½ pints of solution per sq. ft. should be used if the soil is dry instead of 2 pints. On the whole sulphuric acid gave the best results, but is useless on calcareous soils.

Timbers

Rhodesian Timbers.—The *Interim Report of the Rhodesia Munitions and Resources Committee*, 1915–16, p. 17, contains some interesting notes on the indigenous timbers of Northern Rhodesia. The most abundant of the native hardwoods is Rhodesian teak or redwood (*Baikiaea plurijuga*, Harms., Nat. Ord. Leguminosæ). It is used largely for work in contact with the ground, as it resists well the attacks of white ants, and is specially suitable for railway sleepers. Rhodesian mahogany (*Afzelia cuanzensis*, Oliver, Nat. Ord. Leguminosæ) is an evergreen tree commonly found in Barotseland, and widely distributed in the sand-belts. It yields a fairly hard timber, usually handsomely figured, suitable for cabinet-work and joinery. Blood wood or "mukwa," commonly known as paddle wood, derived from *Pterocarpus angolensis*, DC. (Nat. Ord. Leguminosæ), is used by the natives for boat-building and for paddles. It is a first-class wood for joinery and cabinet-work, and is stated to be gaining an increasing reputation in Northern Rhodesia for these purposes. The tree is found singly or in small groups scattered through the sand-belts. "Mangura" is the Barotse name of a yellowish wood, of tough fibrous nature, admirably suited for handles, spokes, etc. Pick and hammer handles made from this wood have been reported on by the Rhodesia Railways as being superior in appearance and toughness to the imported articles. It is thought that the whole of the Rhodesian requirements in this respect can probably be met from this source. The tree grows in the more inaccessible parts of the Barotse Plateau, in some localities almost to the exclusion of other timbers; but it is considered that regular supplies of the wood will be forthcoming shortly. The botanical identity of the tree yielding "mangura" wood is

not known. Other timbers of possible commercial value are "mashuma" (*Diospyros* sp.), which attains a large size in the Zambesi Valley, and is suitable for wagon building and similar purposes; "mangwe" (*Terminalia sericea*, Burch., Nat. Ord. Leguminosae); and numerous hardwoods producing poles suitable for pit-props and similar purposes.

Mahogany.—*Bulletin No.* 474, 1917, *U.S. Dept. Agric.*, deals with the botanical sources, geographical distribution, characters and uses of the wood, methods of logging, etc., of the true mahogany. This timber is produced by two closely related trees, *Swietenia Mahagoni*, Jacq., and *S. macrophylla*, King, formerly regarded as a single species under the former name. Commercially, no distinction is made between the two woods, the timber being classified according to its country of origin. Generally speaking, the small-leaved species (*S. Mahagoni*) is found in Florida, the West Indies, Central and South America and elevated parts of Mexico. It is common at elevations of from 5,000 to 4,000 ft., where it grows slowly, but produces wood of the best quality. The commercial distribution of the large-leafed species (*S. macrophylla*) is not so well known, but it appears to be most abundant in British Honduras and along the coastal plains of Southern Mexico. Mahogany requires about 100 to 150 years to reach merchantable size, and, although it has been planted in India, tropical Africa and elsewhere, it is not considered that the planting of the tree on a commercial scale would be a profitable undertaking. Even in its natural habitat planted trees are often inferior in growth to those resulting from natural seeding. The character of the wood varies according to the country of origin, the marked differences in colour and weight being due to the rate of growth, which in turn is dependent on soil and climatic conditions. Mahogany, for example, produced on the hard, dry limestone soil of Southern Florida grows very slowly, and is hard, heavy, dark red and beautifully figured. The mahogany of Cuba and San Domingo grows in a richer, moister soil, and is usually somewhat softer and of lighter weight than that from Florida, whilst the wood produced in those parts of Mexico and British Honduras where the conditions are very favourable to plant growth is considerably lighter in weight and often much lighter in colour than that from more elevated regions. Mexico produces larger mahogany trees and a greater yield of timber per acre than any other country; the wood, on the whole, is lighter in colour than that from other regions, the best produced in the country, as regards size, colour and weight, coming from the interior and higher portions of the State of Tabasco. Honduras wood also often reaches a large size; it has a beautiful dark colour, with a more or less wavy figure. Mahogany

from Venezuela and San Salvador is of good quality, being hard, heavy and dark brown in colour. That from British Honduras is straight-grained, often devoid of annual rings and free from knots; it is moderately soft and light in weight, and in quality and colour compares favourably with that from Venezuela.

A list is given of 61 species of trees which yield timbers resembling true mahogany, many of which, if not the majority, are marketed as mahogany of the particular region or country from which they are obtained.

ECONOMIC MINERALS

Gemstones. — According to the *Ann. Report Mines, Queensland*, 1916 (*Queens. Govt. Min. Journ.*, 1917, **18**, 117), there was a marked revival in sapphire mining in the Anakie district of Central Queensland during the year. Markets have been established in England and France and all classes of stone produced on the field find a ready sale.

The prices obtained on the London and Paris markets have enabled buyers to give practically the same price as before the war, in spite of the great risk to shipping that causes much higher freights and insurance rates. It is noteworthy that the loss of the German markets, and the prohibition of the exportation of sapphires to neutral countries, have not brought down the price of the gems on the field.

As to the future of the Anakie sapphire industry, there are extensive reserves of gem-bearing ground yet untouched; and though, as time goes on, the production of the gems requires more labour, it is expected that, with improved facilities for treatment, these reserves will ultimately yield a good return. The value of the output for 1916 is estimated at £14,733.

For an article dealing with the sapphire deposits and mining industry of Anakie, see this BULLETIN (1916, **14**, 253).

The *Ann. Rep. Government Geologist, South Australia*, 1915, mentions a discovery of precious opal at Stuart's Range at a place 81 miles west by south of Anna Creek Railway Station and 116 miles north by east of Tarcoola. The specimens examined at Adelaide resemble those obtained at White Cliffs in New South Wales, and it is inferred that they have been derived from the Desert Sandstone formation, which extends across western Queensland and New South Wales into the northern portion of South Australia.

The discovery is regarded as of special importance on account of the fact that the Upper Cretaceous Desert Sandstone, which occupies an immense area in the north-

eastern part of South Australia, has not hitherto made any contribution to the mineral production of the State.

The specimens examined show a sufficiently large proportion of precious opal to justify careful prospecting, and it is reported that they have been obtained over a large area.

Gold.—The total gold production of the Federated Malay States for 1916 as reported by the Senior Warden of Mines to the Secretary of State for the Colonies was 17,386 oz., valued at £67,373 (gold at £3 17s. 6*d.* per oz.). The producing districts and their outputs were as follows: Batang Padang, Perak, 1,085 oz.; Seremban, Negri Sembilan, 120 oz.; Raub, Pahang, 16,181 oz.

The total output for 1915 was 18,641 oz., valued at £72,234.

Iron Ore.—In a memoir dealing with a part of the district of Lake St. John, Quebec, by J. A. Dresser (*Memoir* 92, No. 74 *Geological Series, Dept. of Mines, Canada*, 1916), Professor A. Stansfield discusses the possibility of electric smelting as a means of utilising the iron ore of the St. Charles deposit in Quebec.

This deposit is one of titaniferous magnetite occurring as large segregation masses in anorthosite or gabbro. Estimates of the amount of ore available are uncertain, but it is considered likely that there will be 1,000,000 tons, or possibly as much as five times this amount.

A sample of the ore was found to contain 50·53 per cent. of iron, and 10·55 per cent. of titanium, with 0·02 per cent. of sulphur and 0·03 per cent. of phosphorus. After crushing to pass a 20-mesh sieve, and concentrating magnetically, a concentrate amounting to 77 per cent. of the original ore was obtained. The following table of analyses shows the composition of the concentrate and tailings thus obtained. The composition of the original ore is also given for comparison:

		Original ore. *Per cent.*	Concentrate, 77 per cent. *Per cent.*	Tailings, 23 per cent. *Per cent.*
Iron	Fe	50·53	56·2	30·9
Titanium	Ti	10·55	8·3	19·7
Silica	SiO_2	5·2	3·2	11·4
Alumina	Al_2O_3	4·4	2·7	9·6
Lime	CaO	2·4	1·5	5·3
Magnesia	MgO			
Sulphur	S	0·02	0·015	0·04
Phosphorus	P	0·03	0·015	0·08

These analyses show that, with or without magnetic concentration, the material available for smelting is a

titaniferous magnetite with a moderate amount of gangue and only small amounts of sulphur and phosphorus.

In the past the titanium present in ores of this character has been an obstacle to their use in blast-furnace smelting (see p. 92); but, in view of the various tests that have been made with the blast furnace and the electric furnace, Prof. Stansfield thinks it safe to infer that a titaniferous magnetite can be smelted readily in an electric furnace with charcoal for the production of high-grade pig iron.

The following are the conclusions reached by Prof. Stansfield as regards the possibility of utilising the St. Charles titaniferous magnetite by electric smelting:

The ore is low in sulphur and phosphorus; there is sufficient of it to feed an electric furnace plant for many years, and it is conveniently situated for treatment in this way, the chief obstacle to its use being the 10 per cent. of titanium which it contains.

By crushing, magnetic concentration, and sintering, a product can be obtained, at a cost of about $3 a ton, that is mechanically suitable for smelting in blast or electric furnaces, is lower in phosphorus than the original ore, and contains about 8 per cent. of titanium and 56 per cent. of iron.

This product could be shipped to Sydney or some other blast-furnace plant, and used to the extent of about one-eighth in admixture with non-titaniferous ores, provided that the cost was not too high. Such an addition would lower the phosphorus and improve the quality of the resulting pig iron.

The sintered concentrate could be transported about 14 miles, by a railway which is to form part of a development scheme, to a point at the head of the Saguenay navigation, where electric furnaces (or charcoal blast furnaces) could be erected.

The titaniferous concentrate can be smelted in an electric furnace or a charcoal blast furnace, with suitable fluxes, for the production of low-silicon white pig iron, suitable for making chilled castings or for steel-making; but it will not be practicable to produce a grey or foundry iron from this ore.

It is probable, in view of the results obtained in Sweden, that the electric furnace can be operated at least as cheaply as the charcoal blast furnace; more iron can be produced from a given supply of charcoal, and the resulting iron will be more free from phosphorus if the electric furnace is employed.

A suitable plant would consist of three 4,000 horse-power Elektrometall furnaces. It would produce about

60 tons of iron a day, or 22,000 tons per annum, and would require 140 tons of crude ore, 40 tons of limestone, and 25 tons of charcoal per day. Such a plant would cost about \$360,000. The charcoal could be produced by charring 50 cords of hardwood per day. A sulphite pulp-mill is situated at the adjacent village of Jonquières. The by-products would be 10,000 lb. of acetate of lime (equal to 2,000 lb. of acetone) and 400 gallons of wood alcohol per day. Charcoal should be produced at a cost of \$7 or \$8 per ton, but \$10 has been allowed in the calculation of costs.

The total cost of a ton of pig iron made by this process would be about \$21. Thus the iron could probably be sold at a profit at the prices paid for specially high-quality charcoal pig iron.

The present market in Canada for iron of this price would not absorb more than one-third of the proposed output; but, in view of the rapid developments now taking place in Canada, it seems probable that a larger market could be built up in a few years.

A third or a half of the output could be converted into high-grade steel in an electric furnace, or in an open-hearth furnace heated by the waste gases from the smelting furnace, employing a moderate amount of steel scrap.

The tailings from the magnetic concentration of the ore can be utilised in part for the production of ferro-titanium in an electric furnace (cf. this BULLETIN, p. 87).

Molybdenum Ore. — In the *South African Journ. Sci.* (1916, **13**, 153), Dr. A. L. Du Toit deals with a peculiar occurrence of molybdenum ore in the Hlatimbe Valley, a tributary of the Umkomaas River, in Impendhle County, Natal. The deposit is one of coarse sandstone belonging to the Molteno division of the Karroo System, of Upper Triassic age, and is associated with oil-shale, which overlies the sandstone.

The sandstone bed is 18 ft. thick, but only the lowest four or five feet of it are impregnated with molybdenic material. The exact boundaries of the deposit have not been determined, but it appears to be of irregular shape and small size. The impregnated sandstone is black, owing to the presence of carbonaceous matter with which finely divided molybdenite is associated. A considerable amount of marcasite (rhombic disulphide of iron) is present.

Along certain bands in the sandstone the quartz grains are set in a matrix of kaolinite, the formation of which has resulted from the alteration of potash felspar, which is a common constituent of the sandstone. An analysis of a sample of the sandstone gave:

		Per cent.
Silica	SiO_2	83·8
Alumina	Al_2O_3	0·8
Sulphur	S	4·4
Iron	Fe	2·9
Molybdenum	Mo	1·1

It is estimated from this analysis that the sample contained 6·53 per cent. of pyrite or marcasite and 1·85 per cent. of molybdenite.

Molybdic ochre and aluminite occur as products of alteration; but the most interesting of these decomposition products is the rare mineral ilsemannite ($MoO_2 . 4 MoO_3$) which is soluble in water, and which forms a thin incrustation on the exposed face of the sandstone.

Dr. Du Toit is of opinion that no definite suggestions can be made to explain the origin of this peculiar deposit of molybdenite-bearing sandstone.

Petroleum. — In a recent "Report on the Oil-fields Region of Egypt," published by the Survey Department (Cairo, Government Press, 1916), Dr. W. F. Hume, Director of the Geological Survey of Egypt, deals with the geology of the Suez Gulf region from the standpoint of the occurrence of petroleum.

Dr. Hume describes the Gulf of Suez as a long, deep groove filled with a series of marls, salt and gypsum, and reef formations of Miocene and Pliocene age, lying between two great regions (Red Sea Hills and Sinai) composed of granites and ancient metamorphic rocks, which are probably pre-Cambrian, but occupy their present position owing to relatively recent movements.

He infers that the region suffered depression during late Mesozoic and early Tertiary times, and that during this depression the Nubian sandstones, succeeded by limestones and other strata of Cretaceous and Eocene age, were laid down on the old platform of granite, and metamorphic rocks. At the close of the Eocene a simple folding took place in the region of Egypt and Sinai. This resulted in the formation of a syncline in Central Egypt, the axis of which lay along the present Nile Valley; and an anticlinal arch in the region of the Red Sea Hills and Sinai, the axis of which lay along the present Gulf of Suez and the Red Sea.

The region of the anticlinal arch then suffered erosion, and by subsequent movement became buried under the waters of the Lower Miocene sea, which flowed in from the Mediterranean side. The area was afterwards cut off from the Mediterranean, and as a result of this, gypsum and salty clay were deposited in large quantities.

At a later period, during the Middle Pliocene, further folding took place, and the region assumed its present structure. The axis of Pliocene folding lay along the Gulf of Suez, towards which the granite ridges on either side of the Gulf were overfolded, with the result that they now form asymmetrical flexures.

The indications of petroleum are most conspicuous on both shores of the Gulf of Suez, in the areas of the overfolded anticlines just referred to. The richest supplies of oil have been obtained from dolomitic limestones connected with gypsum deposits of Miocene age or where sands underlie the gypsum. The belts of country at Jemsa and Rarquada, where oil has been found in paying quantities, have the north-west to south-east extension characteristic of the folds of the region.

Dr. Hume suggests that the Miocene strata, and any reservoir rocks immediately adjoining them, are those which deserve closest attention, especially where there is evidence of strong folding; but he refrains from giving an opinion as to the probable future value of the Egyptian oil-fields.

Platinum. — In the *Rec. Geol. Surv., New South Wales* (1916, **9**, 127), J. C. H. Mingaye reports on an occurrence of platinum, palladium and iridium in copper ore. The sample examined consisted of copper carbonate and ironstone, and was obtained in the Broken Hill district. The ore is rich in copper, and contains a small amount of nickel —less than 1 per cent. The silver button obtained on assay was observed from its frosted appearance to contain platinum or platinoid metals, and an assay of it yielded the following results:

	oz.	dwts.	grs.	
Fine silver	16	0	0	per ton of ore
Platinum	0	7	20	,, ,, ,, ,,
Iridium	0	8	20	,, ,, ,, ,,

The ore also contains palladium, and the amount of this element is probably in excess of the platinum and iridium. Similar occurrences have been reported on previous occasions at Broken Hill, and it has already been pointed out that if the ore exists in sufficient quantity it should pay to extract the copper and silver, and obtain the platinum and other precious metals as by-products.

Tungsten Ore. — *No. 1 Mineral Resources, Tasmania, Part III. (Dept. of Mines, Geol. Surv.,* 1916), by L. L. Waterhouse, deals with a deposit of scheelite in King Island. Parts I and II of the series have already been noticed in this BULLETIN (1916, **14**, 487).

King Island is situated in Bass Strait, about midway between Tasmania and Victoria. The locality of the scheelite deposit is on the sea-coast, in the south-eastern part of the island, at the mouth of the Grassy River, and about 2 miles south-west of Bold Head.

The rock formations of the district include both sedimentary and igneous types. Granite crops out for 7 or 8 miles along the coast to the south of the deposit, and appears to extend inland for at least 2 miles. Old slates and sandstones extend to the north for some distance, succeeded by a series of tuffs and igneous breccias about 3 miles north of the deposit. The granite is traversed by occasional acid and basic dykes.

The scheelite deposit is in the sedimentary rocks, about twelve chains from the margin of the granite which has metamorphosed the sediments.

The ore deposit, which consists largely of garnet, has been partly opened up in a position which offers distinct advantages for economical mining. The width of the deposit so far proved is 65 ft. at right angles to the dip, and 85 ft. as exposed by horizontal cross-cuts. The scheelite is present in the garnet deposit partly in disseminated form, and partly in rich masses in quartz veins traversing the deposit.

The ore, as exposed, was found to contain on the average 1·69 per cent. of tungstic acid. The richer masses of scheelite in the quartz veins may tend to increase the average value beyond this figure. The ore does not appear to offer any special difficulties to treatment, and a large percentage of the scheelite present should be saved. The tests that have been made indicate that, if necessary, electro-magnetic separation could be adopted to separate the garnet from the scheelite. In addition to scheelite, the ore contains a little molybdenite, but not enough to be of economic value.

Associated with the main ore-body is a dyke of aplite which contains a little scheelite, but samples of this hitherto examined have not given promising results.

It is worthy of note that, apart from the main ore-body, at least two other scheelite-bearing garnet formations exist on the property, one of which carries promising values at the only point where it is exposed. It thus appears that the district is well worthy of further prospecting, with a view to the discovery of other scheelite ore-bodies along the area of contact with the granite.

NOTICES OF RECENT LITERATURE

AUSTRALIA. By J. W. Gregory, F.R.S., Professor of Geology in the University of Glasgow. Pp. 156, small 8vo. (Cambridge: University Press, 1916.) Price 1*s.* 3*d.*; post free, United Kingdom and abroad 1*s.* 6*d.*

This book is one of the series of Cambridge Manuals of Science and Literature. Prof. Gregory's qualifications for writing on Australia are his first-hand knowledge of the country—he was Professor of Geology and Mineralogy at Melbourne University from 1900 to 1904—and his sympathies with the guiding principles which underlie the interesting social and political developments which have taken place in Australia in recent years—developments which have not always been clearly understood in this country. In this connection it is interesting to note that Prof. Gregory was at one time appointed Chairman of the Wages Board for the wood-working trade in Victoria, and though he did not serve, his selection for such work is a clear indication that his reputation in Australia was much more than that of a competent geologist.

The book deals briefly and clearly with the history of Australia, the physical structure of the country, its fauna and flora, the aborigines, the chief economic products, and finally the political condition and prospects of the country. In his remarks on Australian Universities the author takes the rather unusual but sound view that, though these institutions tend to become great professional schools, this is no educational disadvantage "provided the work be maintained at a high standard; for culture and the principles of science can be taught at least as well by the study of those subjects which are of practical value, as of those in which the interest is purely theoretical." This is typical of the broad and enlightened views taken by the author on a subject which is now receiving a great deal of attention not only in Australia but also in England, and is a wholesome corrective to the view which finds many adherents in this country that knowledge should be sought for its own sake and without regard for practical applications.

Prof. Gregory has made a most useful contribution to the popular literature on a Dominion which has taken a great share in shouldering the burdens of the war, and is behind no part of the Empire in its high conception of its duties to its citizens.

BENGAL, BIHAR AND ORISSA, SIKKIM. By L. S. S. O'Malley, of the Indian Civil Service. Pp. xii + 317, Crown 8vo. (Cambridge: University Press, 1917.) Price 6*s.* net; post free, United Kingdom 6*s.* 5*d.*, abroad 6*s.* 6*d.*

Two previous volumes of the "Provincial Geographies of India" series, to which this volume belongs, have already

been published. The first volume dealt with the Madras Presidency and Associated States, and the second with the Punjab, N.-W. Frontier Province and Kashmir (see this BULLETIN, 1916, 14, 645). The present volume covers the newly constituted province of Bengal, and the closely related districts of Bihar and the two divisions of Chota Nagpur and Orissa. The subject-matter is arranged on the plan adopted for the preceding volumes, and treats not only of the physical aspects of the country but of the flora and fauna, the peoples, their history, religions, languages, industries and commerce, communications, and the methods of administration. There is also a "roll of honour" of names "worthy of being had in remembrance because they have made modern history in the two provinces."

Although the area dealt with comprises only one-ninth of the total area of India, yet it represents an area nearly equal in extent to the whole of the German Empire, whilst the population numbers nearly 85,000,000. These provinces are rich in minerals, nearly nine-tenths of the coal of India being obtained from the coal-fields of Bengal, Bihar and Orissa, whilst from the districts of Hazaribagh, Gaya and Monghyr, in Bihar, about one-third of the world's supply of mica is derived. Other important minerals are iron, manganese, gold and copper, slate and limestone; whilst from saliferous earth found in North Bihar saltpetre is prepared and this has formed an important article of export from India from early times.

The most important industries are those connected with jute, cotton and tea, the products of these industries forming the bulk of the exports from Calcutta. Bihar has practically a monopoly of natural indigo production, which since the war has to some extent recovered its importance, and there is a considerable cultivation of lac in Chota Nagpur.

As in the case of other parts of India, agriculture is of supreme economic importance, some 35,000,000 people in Bengal and 30,000,000 in Bihar and Orissa subsisting on the cultivation of the land. Rice and jute are the most important crops in Bengal, whilst wheat, barley and maize are extensively grown in Bihar. Millets, pulses, oil seeds, sugar-cane, tobacco and indigo are other native crops. Cinchona is grown at Darjeeling on behalf of the Government, whilst tea is the principal planting industry.

Within the space at his disposal, the author has succeeded in giving a very readable and accurate account of the important division of India dealt with in this volume. As in the case of the preceding volumes, the outline key-maps serve to elucidate the text, but the illustrations are not always as well printed as they might be.

THE GUIDE TO SOUTH AND EAST AFRICA FOR THE USE OF TOURISTS, SPORTSMEN, INVALIDS AND SETTLERS. Edited by A. Samler Brown and G. Gordon Brown for the Union-Castle Mail Steamship Co., Ltd., 1917 edition. Pp. li + 773, Crown 8vo. (London: Sampson Low, Marston & Co., Ltd.) Price 1*s.* net; post free, United Kingdom 1*s.* 5*d.*, abroad 1*s.* 7*d.*

This well-known guide-book, which has now reached its 23rd edition, is divided into three parts. The first, under the heading "South Africa," deals with the Union of South Africa, the Protectorate of South-west Africa, Rhodesia, the Katanga district of the Belgian Congo and Portuguese West Africa (Angola). It gives information as to railways, history, climate, statistics, acquisition of land, farming, forestry and mining, followed by a description of the chief towns and their environs, the remainder of the area described being divided for the purpose into thirty-six routes. The second part of the book deals in a similar manner with "East Africa," which heading includes the Sudan, Nyasaland and Uganda, as well as British, Portuguese and German East Africa. The concluding part deals with the big game of South and East Africa, the Game Laws, the fauna, fishing, whaling, etc. The section on the fauna is particularly valuable, being much fuller than is usual in books of this type.

There are numerous excellent maps and plans, and a very full general index as well as a separate index to the fauna. The book can be thoroughly recommended as a reliable and useful guide to those visiting the countries dealt with, and will also prove of interest to the general reader.

FIELD-CROPS FOR THE COTTON-BELT. By J. O. Morgan, M.S.A., Ph.D., Professor of Agronomy in the Agricultural and Mechanical College of Texas. Pp. xxvi + 456, Crown 8vo. (New York: The Macmillan Company, 1917.) Price 7*s.* 6*d.* net; post free, United Kingdom 8*s.*, abroad 8*s.* 3*d.*

This book, which is one of the Rural Text-book Series, edited by L. H. Bailey, is adapted primarily for the needs of the college student of the Southern United States, but will also be found of value to the farmer. Cotton and maize are by far the most important crops of the "cotton-belt," and they are consequently considered in much more detail than the other crops dealt with, which comprise oats, wheat, rye, barley, rice, the sorghums, sugar-cane, and ground-nut. In the section on cotton, for example, which occupies nearly 150 pages, separate chapters are devoted to a description of the cotton plant, its physiology, the principal species cultivated throughout the world, the varieties of American Upland cottons, breeding, soils and climatic conditions, manures and rotations, tillage, harvesting and marketing, insect pests and fungoid diseases. The

account of the cultivation of the plant will be found of value to planters in those parts of the British Empire where American varieties are being grown, as indicating the methods practised in the "home" of this grade of cotton. The book is essentially one for the grower, practically no attention being paid to the uses of the crops.

A HAUSA BOTANICAL VOCABULARY. By John M. Dalziel, M.D., D.Sc., D.T.M. Pp. 119, Demy 8vo. (London: T. Fisher Unwin, Ltd., 1916.) Price 6*s.* 6*d.* net; post free, United Kingdom and abroad 6*s.* 10*d.*

Dr. Dalziel, who is attached to the West African Medical Staff, has made a special study of the flora of the Northern Provinces, Nigeria, and has paid particular attention to plants of economic value. The results of much of this work are incorporated in the present volume, which gives the Hausa names of the more common plants, both wild and cultivated, of the region mentioned, and of the products obtained from them, their botanical names where known, and a brief description of the plants and their native uses. The plants are arranged alphabetically under their Hausa names, and there is a complete index to their generic and English names.

As an example of the method of treatment followed, the entry relating to the ground nut may be quoted: "**geda** (Kano, etc.), **gyada** (Sok.), *Arachis hypogaea*, L. (Leguminosæ). 'Ground nut,' 'Monkey nut,' 'Arachides,' 'Earth-pea.' In Sokoto usually called **gujiya**, *q.v.* Eaten raw or roasted or prepared in various ways. *man geda* = the expressed oil, used for cooking and as an illuminant; *harawar geda*, ground nut hay, a valuable dry-season fodder; *kwalli kwalli*, balls or rings like doughnuts, made of ground-nut paste fried in oil. *gujiya kolanche* (Sok.), a var. of **geda** with long pods."

Books of this type are particularly valuable, not only to the student of native languages but to the trader and merchant in the country concerned, and it is to be hoped that the useful plants of other parts of the British tropical possessions will be dealt with in a similar manner.

MICROSCOPICAL DETERMINATION OF THE OPAQUE MINERALS. By Joseph Murdock, Ph.D. Pp. vii + 165, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 9*s.* 6*d.* net; post free, United Kingdom and abroad 9*s.* 11*d.*

This very useful book gives an account of the characters of opaque minerals, and the methods by which they are studied. The first part of the book (47 pages) is devoted chiefly to the technical methods of examination, and includes instructions for polishing, mounting, magnification,

photography, colour comparison, hardness determinations and microchemical tests. The second part of the book consists of tables for use in the identification of minerals. A broad classification based on colour is adopted, chemical and hardness characteristics being made use of for distinctive tests. "The main divisions of the classification, *coloured*, *white* and *grey*, are indicated by the tabs of a thumb index at the top of the book. These are the only tabs on the *upper* margin of the page, all others being on the *outer* margins. The first step in using the tables is to open them to the beginning of one of the main divisions, by holding down with the thumb the appropriate tab. This exposes the first subdivision, marked by a series of tabs on the *outer* margin of the *right-hand* page. One of these tabs is then similarly held down, and the tables opened to the page carrying the tab, revealing the tabs of the second subdivision on the outer margin of the *left-hand* page. This procedure is continued, the tabs alternating from right to left until no more new sets appear, showing that the last subdivision has been reached."

The reader will perceive from this account that the book aims at being a thoroughly practical guide. It is rather difficult to know how one should define opacity in relation to minerals, but even making allowance for this difficulty a practical mineralogist may be excused for wondering why certain of the minerals included should be classed as opaque and why certain opaque minerals of importance have not been included. This is a minor matter, however, and the book is sure to be well received as a record of work on a subject that has been very actively studied in the United States in recent years. It will be particularly useful to mining geologists and others who are interested in the study of opaque ore minerals.

A Pocket Handbook of Minerals. By G. Montague Butler, E.M. Pp. ix + 311, Fcap. 8vo. 2nd edition. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., no date.) Price 11*s.* 6*d.* net; post free, United Kingdom and abroad 11*s.* 10*d.*

This is the second thousand of the second edition of a handy little pocket-book, the first edition of which was published in 1908. The book is limited to a description of the more important minerals, and gives the chief characteristics by which they may be identified. Little or no information is given as to occurrence and distribution, presumably because the chief purpose in view is to keep the book of handy size for the pocket. The book is provided with blank spaces for notes, which are perhaps less useful than would have been the extra information that the author might have given. At the end of the book are a glossary and a tabular arrangement of minerals to aid identification.

Several additions have been made to the species described, as, for example, such useful minerals as autunite and torbernite, but no place appears to be given to these additions in the index. To quote the preface, the book is not intended to be used as a manual of mineralogy, but is planned to supplement lectures on the subject, serve as a notebook on the same, and to be useful to collectors or mining men who have not had previous training in the subject. The book is illustrated by means of small drawings of crystals and photographs of specimens.

THE AWAKENING OF AN EMPIRE. By Robert Grant Webster, LL.B., J.P., F.R.C.I., formerly Member of Parliament for East St. Pancras. Pp. xxvi + 326, Crown 8vo. (London: John Murray, 1917.) Price 6*s.* net; post free, United Kingdom and abroad 6*s.* 5*d.*

In this work the author points out what in his view constitute the more serious defects in the present economic system of the British Empire, and suggests a reconstructive policy designed to ensure the unhampered development of the various parts of the Empire, the restoration of wealth and prosperity to the countries allied with us in the present conflict, and restriction of the admission of the natural resources of the Empire into Germany. The following are the salient features of the scheme: It is proposed that an inter-Imperial system of tariffs should be arranged. A general customs tariff should be established within the United Kingdom, and every unit of the Empire should be allowed to adopt its own fiscal policy to suit its own conditions, whilst giving more favourable treatment to other parts of the Empire than to foreign countries. Preferences could be given to countries within the Empire, to the Allies and to friendly neutral Powers as far as possible on the principle of reciprocity. With regard to Germany, no goods from that country should be admitted into the United Kingdom, except by special permission of the Government and on terms to be decided on. By these means, in conjunction with certain minor reforms, such as the improvement of Company Laws, the adoption of the metric system of weights and measures, and an increased study of foreign languages and customs, the author considers that a well-balanced system of mutual interchange of commodities could be arranged which would be to the advantage of all the countries concerned and would lead to the establishment of continuous and increasing commercial intercourse.

The book is written in a clear and interesting manner and forms a useful commentary on the important questions of trade relations and fiscal policy which must be faced by the British Empire and the Allies generally at the close of the war.

BOOKS RECEIVED

Intensive Farming in India: A Manual on the Cultivation of Rice, Cotton, Wheat, Sugar-cane, Tobacco, Tea, Coffee, Coconuts, Potatoes and Onions. By John Kenny, Director of Agriculture, Hyderabad, Deccan. 2nd ed. Pp. viii + 611 + xi, Demy 8vo. (Madras: Higginbothams, Ltd.; London: Luzac & Co., 1916.) Price Rs. 6; post free, United Kingdom 8s. 5*d.*, abroad 8s. 8*d.*

Seeding and Planting: A Manual for the Guidance of Forestry Students, Foresters, Nurserymen, Forest Owners and Farmers. By James W. Toumey, M.S., M.A., Director of the Forest School and Professor of Silviculture, Yale University. Pp. xxxvi + 455, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 16*s.* 6*d.* net; post free, United Kingdom 17*s.*, abroad 17*s.* 6*d.*

Handbook for Rangers and Woodsmen. By Jay L. B. Taylor, Forest Ranger, United States Forest Service. Pp. ix + 420, Fcap. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1917.) Price 11*s.* 6*d.* net; post free, United Kingdom and abroad 11*s.* 10*d.*

British Forestry, Past and Future. A Paper read before the Worshipful Company of Carpenters on April 4, 1917. By William Somerville, M.A., D.Sc., Sibthorpian Professor of Rural Economy in the University of Oxford. Pp. 19, Roy. 8vo. (London: Humphrey Milford, 1917.) Price 6*d.*; post free, United Kingdom and abroad 6½*d.*

La Nostra Pace Coloniale. L'Italia e l'Alleanza in Oriente e in Africa. By Giuseppe Piazza. Pp. 133, Crown 8vo. (Rome: Casa Editrice *Ausonia*, 1917.) Price lire 2·50; post free, United Kingdom and abroad 2*s.* 2*d.*

South African Exploration. 5th Series. *South Africa* Handbooks, No. 86. Pp. 28, Roy. 16mo. (London: *South Africa* Offices, 1917.) Price 6*d.*; post free, United Kingdom and abroad 6½*d.*

Directory of Paper Makers of the United Kingdom for 1917. 41st annual publication. Pp. 236, Imp. 8vo. (London: Marchant Singer & Co., 1917.) Price 1*s.* net; post free, United Kingdom 1*s.* 5*d.*, abroad 1*s.* 8*d.*

Year Book of Wireless Telegraphy and Telephony, 1917. Pp. cx + 928, 8vo. (London: The Wireless Press, Ltd.) Price 3*s.* 6*d.* net; post free, United Kingdom 4*s.* 1*d.*, abroad 4*s.* 7*d.*

A Pocket Book for Chemists, etc. By T. Bayley, A.R.C.Sc.I. 8th ed. Edited by Robert Ensoll, F.C.S., Assistant Chemist to British Dyes, Ltd. Pp. xvi + 425, Fcap. 16mo. (London: E. and F. N. Spon, Ltd., 1917.) Price 7*s.* 6*d.* net; post free, United Kingdom and abroad 7*s.* 9*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian and other Governments concerned.

THE IMPROVEMENT OF COTTON IN INDIA.—II

In a previous number of this Bulletin (1912, 10, 351) an account was given of experiments which were being carried out in various parts of India in connection with the improvement of cotton and a large number of specimens of cotton produced in Madras, Central Provinces, United Provinces, Bengal, Assam and Burma, which had been examined at the Imperial Institute, were described. Since that date further samples from Madras, Central Provinces and Berar, United Provinces and Burma have been received, as well as cottons from the Punjab and Bombay, and an account of the results of examination of these is given in the following pages.

Madras

Selection experiments with indigenous varieties of cotton have been carried on for some years at several Government Agricultural Stations in the Madras Presidency, and a series of 27 samples grown at these stations and elsewhere in the Presidency was received for examination in September 1912. Each sample, except Nos. 6, 12 and 24, consisted of both ginned and unginned cotton. The results of the examination of the samples are shown in Table I (pp. 150–153).

The samples were similar to one another in general character, and were, on the whole, of satisfactory quality. The length was in most cases about 1 in., but the greater proportion of the fibres in samples 8, 17 and 26 were shorter and ranged from 0·7 to 0·9 in. In a few instances the staple was rather irregular, this being particularly noticeable in samples 18, 21 and 23. Most of the cottons

TABLE I

RESULTS OF THE EXAMINATION OF 27 SAMPLES OF COTTON EXPERIMENTALLY GROWN IN THE MADRAS PRESIDENCY

No.	Variety.	Where grown.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial classification and value per lb.[1]
1	"P. 3" Broach	Bellary Agricultural Station	28·9 per cent., 2·22 grams per 100 seeds	Clean, fairly soft, fine, lustrous, cream colour, almost free from stains	Small, covered with short silver-grey fuzz	Fairly good	0·7 to 1·3 in., mostly 0·8 to 1·0 in.	"Superfine" Broach. $6\frac{5}{8}d.$
2	"P. 5" Coompta	Do.	28·0 per cent., 2·28 grams per 100 seeds	Clean, fairly soft, fine, moderately lustrous, cream colour, a few light yellow stains	Small, covered with silver-grey fuzz	Fair	0·7 to 1·2 in., mostly 0·8 to 1·0 in.	"Superfine" Coompta. $6\frac{1}{2}d.$
3	"P. 9." A local cross	Do.	29·1 per cent., 2·26 grams per 100 seeds	Clean, soft, fine, moderately lustrous, cream colour with a pale reddish-brown tint, free from stains	Small, covered, with very short silver-grey or brown fuzz	Fairly good	Rather irregular; 0·7 to 1·2 in.	"Strictly fine." $6\frac{1}{8}d.$ to $6\frac{1}{4}d.$
4	"B. 10." A local cross	Do.	33·9 per cent., 3·18 grams per 100 seeds	Clean, fairly soft, fine, moderately lustrous, cream colour with a very slight reddish-brown tint, free from stains	Small, covered with short fuzz of silver-grey, brown, or greenish-brown colour. About 7 per cent. had been attacked by insects	Fair	0·8 to 1·2 in., mostly 0·8 to 1·0 in.	"Strictly fine." $6\frac{3}{8}d.$
5	"B. 11." A local cross	Do.	32·2 per cent., 3·00 grams per 100 seeds	Clean, slightly harsh, fine, moderately lustrous, cream colour with a slight reddish-brown tint, free from stains	Small, in most cases covered with short silver-grey or greenish-brown fuzz; a few bore no fuzz	Fair	Rather irregular; 0·7 to 1·1. in.	"Strictly fine." $6\frac{3}{8}d.$
6	"B. 21." A local cross	Do.	—	Clean, slightly harsh, fine, moderately lustrous, cream colour with a slight reddish-brown tint, free from stains	—	Fair, rather irregular	0·7 to 1·1 in., mostly 0·8 to 1·0 in.	"Strictly fine." $6\frac{3}{8}d.$
7	"Javari, No. 41." A local type	Do.	24·0 per cent., 1·62 grams per 100 seeds	Clean, slightly harsh, fine, good lustre, cream colour with a reddish-brown tint, a few brownish stains	Very small, covered with short silver-grey fuzz	Fair	0·7 to 1·2 in., mostly 0·8 to 1·0 in.	"Fine." $6\frac{1}{2}d.$

8	"Javari, No. 44." A local type	Do.	33·7 per cent., 3·23 grams per 100 seeds	Clean, slightly harsh, fine, moderate lustre, cream colour with occasional slight yellow stains	Small, covered with short silver-grey or greenish-brown fuzz	Fairly good, rather irregular.	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	"Fine." 6d.
9	"Northerns, White, Sircarpathi"	Nandyal Agricultural Station	29·4 per cent., 1·85 grams per 100 seeds	Clean, fairly soft, fine, lustrous, cream colour with a reddish-brown tint, occasional yellow or brownish stains	Small, covered with short silver-grey or brownish fuzz	Good	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	"Fine." 6½d.
10	"Yerrapathi" Red Northerns	Nunapalli Village, Nandyal Talug	23·7 per cent., 1·38 grams per 100 seeds	"Leafy" (*i.e.* containing pieces of broken capsules), soft, fine, moderately lustrous, colour reddish-brown to almost white, a few small yellow stains	Small, mostly covered with moderately long silver-grey or brownish fuzz; a few bore no fuzz. Some had a pink stain, 9 per cent. had been attacked by insects	Fair, rather irregular	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	"Good" ginned Madras Northerns. 5⅞d.
11	"Tellapathi" White Northerns	Do.	25·5 per cent., 1·65 grams per 100 seeds	Rather "leafy," irregular lustre, soft, fine, colour reddish-brown to almost white, a few dark yellow stains	Small, mostly covered with fairly long silver-grey, brownish or greenish fuzz. A few were stained pink, several bore no fuzz	Poor	0·6 to 1·4 in., mostly 0·9 to 1·1 in.	"Fully good" Northerns. 6d.
12	"No. 1"	Hagari Agricultural Station	—	Slightly "leafy," fine, rather harsh, moderate lustre; colour pale reddish-brown to pale cream, many small, yellow or brownish stains	—	Fair	0·7 to 1·2 in., mostly 0·8 to 1·0 in.	"About fine." 6½d.
13	"No. 2"	Do.	26·7 per cent., 2·07 grams per 100 seeds	Clean, fairly soft, fine, fair lustre, cream colour with reddish tint, free from stains	Small, covered with fairly short silver-grey fuzz	Good	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	"Barely fine." 6¼d.

[1] *On the date (January 1913) of the valuation of these samples, the following prices for corresponding commercial qualities of cotton were quoted in the Liverpool market: "Fine" Broach, 6$\frac{9}{16}$d. per lb.; "good" Coompta, 6$\frac{3}{16}$d. per lb.; "middling" American, 6·80d. per lb.*

TABLE I—*continued*

RESULTS OF THE EXAMINATION OF 27 SAMPLES OF COTTON EXPERIMENTALLY GROWN IN THE MADRAS PRESIDENCY

No.	Variety.	Where grown.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial classification and value per lb.[1]
14	"No. 21"	Hagari Agricultural Station	24·7 per cent., 1·99 gram per 100 seeds	Clean, soft, fine, moderately lustrous, light cream colour with reddish tint, free from stains	Medium size, covered with fairly short silver-grey fuzz	Fair	0·7 to 1·1 in., mostly 0·8 to 1·0 in.	"Fine." $6\frac{3}{4}d.$
15	"No. 23"	Do.	27·5 per cent., 2·29 grams per 100 seeds	Fairly clean, fine, lustrous, rather harsh, pale cream colour, a number of small yellow stains	Medium size, covered with short white fuzz	Good	Rather irregular; 0·6 to 1·2 in., mostly 0·9 to 1·1 in.	"Fine." $6\frac{3}{8}d.$
16	"No. 25"	Do.	24·7 per cent., 1·94 gram per 100 seeds	Clean, fine, rather harsh, moderately lustrous, pale cream colour, almost free from stains	Small, covered with short white or brownish-white fuzz	Good	0·7 to 1·1 in., mostly 0·8 to 1·0 in.	"Strictly fine." $6\frac{3}{8}d.$
17	"No. 43"	Do.	29·3 per cent., 2·19 grams per 100 seeds	Clean, fairly soft, fine, silky, fair lustre, cream colour, occasional small yellow or brown stains	Small, covered with fairly short white or greenish-brown fuzz	Good. Some weak, immature fibres present	0·5 to 1·0 in., mostly 0·7 to 0·9 in.	"Fully good" to "fine." $5\frac{7}{8}d.$
18	"No. 44"	Do.	26·6 per cent., 1·86 gram per 100 seeds	Clean, fine, fairly soft, moderately lustrous, pale cream colour with reddish-brown tint, almost free from stains	Small, covered with short silver-grey fuzz	Rather poor	Irregular; 0·5 to 1·1 in.	"About fine." [illegible]$d.$
19	"Bellary Broach"	Do.	Not determined	Clean, fine, rather harsh, fairly good lustre, pale cream colour, almost free from stains	Small, covered with short white fuzz	Fairly good, irregular	Rather irregular; 0·7 to 1·2 in.	"Strictly fine." $6\frac{1}{2}d.$
20	"Surat Broach"	Do.	Not determined	Slightly "leafy," fine, fairly soft, moderate lustre, cream colour, occasional small yellowish and brownish stains	Small, covered with white or brownish fuzz; many withered or attacked by insects	Good	0·8 to 1·2 in., mostly 0·9 to 1·1 in.	"Strictly fine" to "fine." $6\frac{3}{8}d.$

21	"Bellary Lalio"	Do.	28·0 per cent., 2·28 grams per 100 seeds	Fairly clean, fine, moderately soft, rather good lustre, cream colour with reddish-brown tinge, occasional yellow or brownish stains	Small, covered with very short silver-grey, greenish or brownish fuzz	Fair, rather uneven	Rather irregular; 0·7 to 1·4 in., mostly 0·7 to 0·9 in.	"Fine." $6\frac{1}{4}d.$
22	"Bellary Kanvi"	Do.	32·0 per cent., 2·75 grams per 100 seeds	Clean, soft, fine, moderately lustrous, cream colour with pale reddish-brown tint, a large number of small yellow or brownish stains	Small, covered with short white or brownish fuzz	Fair	0·7 to 1·2 in., mostly 0·8 to 1·0 in.	"Fine." $6\frac{1}{4}d.$
23	"Bellary Kumpta"	Do.	26·5 per cent., 2·04 grams per 100 seeds	Clean, soft, fine, lustrous, pale cream colour with slight reddish tint, occasional small, yellow or brownish stains	Small, covered with short white or brownish fuzz	Fairly good, uneven	Rather irregular; 0·8 to 1·6 in.	"Fine" Coompta. $6\frac{3}{8}d.$
24	"Black-seeded"	Do.	—	Clean, soft, fine, moderately lustrous, pale reddish-brown tint	Small, sound, smooth, chocolate colour, very small tufts of short white fuzz at each extremity	Fairly good, rather uneven	Rather irregular; 0·7 to 1·3 in.	"Fully good" to "fine." $6\frac{1}{8}d.$
25	"Surat Kanvi"	Do.	33·2 per cent., 3·07 grams per 100 seeds	Slightly "leafy," fairly soft, fine, good lustre, cream colour, slightly stained	Rather small, covered with fairly short white or brownish fuzz	Good	0·8 to 1·3 in., mostly 0·9 to 1·1 in.	"About fine." 6d.
26	"Surat Lalio"	Do.	32·0 per cent., 2·88 grams per 100 seeds	Rather "leafy," fairly soft, fine, moderately lustrous; pale cream colour, many small yellow and reddish-brown stains	Fairly small, covered with rather short white or brownish fuzz	Fair	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	"Fully good" to "fine." $5\frac{3}{4}d.$
27	"Hagari Broach"	Do.	28·4 per cent., 2·67 grams per 100 seeds	Clean, fairly soft, fine, good lustre, pale cream colour, a few small, yellow and reddish-brown stains	Medium size, covered with short brownish fuzz or white fuzz of medium length	Fair	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	"Fine." $6\frac{1}{2}d.$ to $6\frac{5}{8}d.$

[1] *On the date (January 1913) of the valuation of these samples, the following prices for corresponding commercial qualities of cotton were quoted in the Liverpool market: "Fine" Broach, $6\frac{9}{16}d.$ per lb.; "good" Coompta, $6\frac{3}{16}d.$ per lb.; "middling" American, 6·80d. per lb.*

were of good strength, but samples 11, 18 and 21 were rather less satisfactory in this respect.

CENTRAL PROVINCES AND BERAR

Reference has already been made in this BULLETIN (*loc. cit.*, p. 354) to the selection experiments conducted at the Akola Experiment Farm in Berar. The cottons grown there include the indigenous "jari," which consists chiefly of a mixture of races of *Gossypium neglectum*; "bani" (*G. indicum*), another native form; "buri," an American upland cotton introduced from Bengal, where it is acclimatised; several of the different races of local "jari," viz. *G. neglectum* vars. *malvensis*, *vera*, *rosea* and *cutchica*; a selection known as K.7, produced by the Economic Botanist, United Provinces; and a number of hybrid cottons. Among the latter are crosses between "bani" and "rosea" (raised some years ago at the Talenkheri Farm); "bani" and "mathio"; and "bani" and a white-flowered variety of *G. neglectum*, introduced from the Punjab under the name "deshi Lahore." The last-named hybrid was raised at the Sindewahi Farm, and is called by the Imperial Cotton Specialist "Sindewahi cross." Of the different forms grown at Akola, the "rosea" cotton has almost consistently given the best results so far as the value per acre is concerned; its lint is somewhat inferior to some of the other kinds, but it gives a better yield. According to the Deputy Director of Agriculture, Western Circle, Central Provinces, from 1,500,000 to 2,000,000 lb. of "rosea" seed have been distributed annually through the Agricultural Department during the past three years; the area under "rosea" cotton is now about 700,000 acres, and is increasing at the rate of about 100,000 acres per annum. The total area under cotton in the Central Provinces is about 4,750,000 acres. A number of farmers who have been growing "rosea" cotton for some years on large areas estimated that in 1914–15 the average extra profits gained through the cultivation of this variety in place of the ordinary cotton were over 21*s.* per acre.

The results recorded as obtained at Akola with some of the above-mentioned cottons are shown in the following table:

Variety.	Average outturn of lint during the years 1907–8 to 1915–16.	Outturn of seed-cotton in 1915–16.	Yield of lint in 1915–16.	Value of outturn per acre in 1915–16, based on Nagpur prices.
	lb. per acre.	*lb. per acre.*	*lb. per acre.*	£ *s.* *d.*
G. neglectum malvensis .	138	570	190·4	4 9 9
„ *vera* . .	147	511	171·0	3 14 2
„ *rosea* . .	2[illegible]4	659	267·5	5 9 2
„ *cutchica* .	201	687	255·9	5 1 5
"Berar jari" . .	158	499	172·4	3 9 6
"Saugor jari" . .	147	747	247·6	5 5 7
"Bani" . . .	103	547	148·8	4 19 6
"Buri" . . .	128	539	180·1	5 7 11
"Sindewahi cross" ("Bani × Deshi Lahore")	—	538	184·5	4 17 4

The cottons were grown on plots 0·10 acre in extent, and the land was manured with cattle dung at the rate of 40 lb. of nitrogen per acre.

Specimens of the cotton grown at Akola have been received at the Imperial Institute each year for the past four years. The results of their examination are given in Table II (pp. 156–161).

Some of these selected cottons and crosses, as well as other varieties, have also been grown at the Sindewahi Agricultural Station, Chanda District, Central Provinces. Here again the "rosea" cotton has given good results. The yields at Sindewahi in all cases are much higher than those obtained at Akola. In 1915–16 cotton was grown on both irrigated and non-irrigated land; no manure was applied during the year, but the area had been highly manured in previous years. The results were as follows:

Variety.	Irrigated.		Non-Irrigated.	
	Outturn of seed-cotton.	Value per acre, based on Nagpur prices.	Outturn of seed-cotton.	Value per acre, based on Nagpur prices.
	lb. per acre.	£ *s.* *d.*	*lb. per acre.*	£ *s.* *d.*
"Cambodia"	1,436	17 4 7	941	11 6 3
"Rosea"	2,040	18 7 0	1,497	13 5 11
"Buri"	880	9 16 5	748	8 8 1
"Bani × Rosea, 1,145" .	1,394	14 19 11	1,265	13 10 11
"Sindewahi cross" ("Bani × Deshi Lahore")	1,431	13 18 7	1,239	10 19 9
K.7	1,422	9 14 4	1,112	7 11 10

Specimens of these cottons were received at the Imperial Institute from Sindewahi in 1915 and 1916. The results of their examination are shown in Table III (pp. 162, 163).

TABLE II

RESULTS OF THE EXAMINATION OF 44 SAMPLES OF COTTON GROWN AT THE GOVERNMENT EXPERIMENTAL FARM, AKOLA, BERAR, CENTRAL PROVINCES, RECEIVED IN 1913, 1914, 1915 AND 1916

No.	Variety.	Year.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value. *Per lb.*
1	"Malvensis IV"	1913	29·0 per cent., 2·5 grams per 100 seeds	Clean, fairly fine and soft, moderate lustre, pale cream colour, practically free from stains	Small, covered with short brownish fuzz	Good	0·7 to 1·1 in., mostly 0·7 to 0·9 in.	$6\frac{1}{4}$*d.* (nominal).[1]
2	Do. . .	1914	28·6 per cent., 2·25 grams per 100 seeds	Clean, harsh, fairly lustrous, cream colour, a few small yellowish or brownish stains	Small, covered with greyish or greenish fuzz	Fairly good, somewhat irregular	Slightly irregular, 0·6 to 1·1 in., mostly 0·6 to 0·8 in.	6*d.* (nominal).[2]
3	Do. . .	1915	32·6 per cent., 2·72 grams per 100 seeds	Clean, slightly harsh, fairly lustrous, pale cream colour, almost free from stains	Small, covered with short brownish-grey fuzz	Fairly good	0·6 to 1·1 in., mostly 0·8 to 1·0 in.	$4\frac{5}{8}$*d.*[3]
4	Do. . .	1916	30·8 per cent., 2·8 grams per 100 seeds	Clean, rather harsh, pale cream colour, possessing little lustre	Small, covered with short brownish-grey fuzz, tuft at pointed end	Fair	0·8 to 1·2 in., mostly about 1·0 in.	$6\frac{1}{2}$*d.*[4]
5	"Vera No. 1"	1913	31·8 per cent., 3·1 grams per 100 seeds	Clean, fairly fine, rather harsh, moderate lustre, pale cream colour, free from stains	Small, covered with short brownish fuzz	Good	0·7 to 1·1 in., mostly 0·7 to 0·9 in.	$6\frac{1}{8}$*d.* (nominal).[1]
6	"Vera" .	1914	33·8 per cent., 3·19 grams per 100 seeds	Clean, harsh, moderately lustrous, cream colour, practically free from stains	Small, covered with short greyish-brown fuzz	Fairly good	0·6 to 1·1 in., mostly 0·7 to 0·9 in.	$6\frac{1}{8}$*d.* (nominal).[2]
7	Do. . .	1915	36·7 per cent., 3·08 grams per 100 seeds	Clean, rather harsh, fairly lustrous, cream colour, free from stains	Small, covered with short brown fuzz	Fairly good	0·5 to 1·1 in., mostly 0·7 to 0·9 in.	$4\frac{1}{2}$*d.*[3]
8	Do. . .	1916	31·6 per cent., 3·33 grams per 100 seeds	Clean, harsh, little lustre, pale cream colour	Moderate size, covered with short greenish-grey fuzz	Fair	0·7 to 1·1 in., mostly 0·8 to 0·9 in.	$6\frac{1}{2}$*d.*[4]

9	"Rosea I"	1913	38·7 per cent., 4·7 grams per 100 seeds	Clean, rather coarse and harsh, poor lustre, pale cream colour, almost free from stains	Small, covered with short brown or greenish-brown	Good	0·5 to 1·2 in., mostly 0·7 to 0·9 in.	6*d.* (nominal).[1]
10	Do. . .	1914	39·9 per cent., 4·19 grams per 100 seeds	Clean, harsh, moderately lustrous, cream colour, free from stains	Small, covered with short brown fuzz	Good	0·7 to 1·1 in., mostly 0·7 to 0·9 in.	6*d.* (nominal).[2]
11	Do. . .	1915	41·4 per cent., 4·38 grams per 100 seeds	Clean, harsh, fairly lustrous, pale cream colour, free from stains	Small, covered with short brownish fuzz	Good	0·5 to 0·9 in., mostly 0·5 to 0·7 in.	$4\frac{3}{8}$*d.*[3]
12	Do. . .	1916	40·4 per cent., 4·6 grams per 100 seeds	Clean, harsh, little lustre, pale cream colour, free from stains	Small, covered with short light brown fuzz	Good	0·7 to 1·1 in., mostly 0·8 to 0·9 in.	6*d.* to $6\frac{1}{2}$*d.*[4]
13	"Rosea Cutchica I"	1913	37·2 per cent., 4·4 grams per 100 seeds	Clean, fairly fine, rather harsh, moderate lustre, pale cream colour, almost free from stains	Small, covered with short brown or greenish-brown fuzz	Fairly good	0·5 to 1·1 in., mostly 0·7 to 0·9 in.	$5\frac{7}{8}$*d.* (nominal).[1]
14	Do. . .	1914	37·9 per cent., 4·04 grams per 100 seeds	Clean, very harsh, moderately lustrous, cream colour, free from stains	Small, covered with short greyish-brown fuzz	Fair	0·5 to 0·9 in., mostly 0·5 to 0·7 in.	6*d.* (nominal).[2]
15	Do. . .	1915	39·8 per cent., 3·45 grams per 100 seeds	Clean, rather harsh, moderately lustrous, pale cream colour, free from stains	Small, covered with short greyish-brown fuzz	Good	0·5 to 0·8 in., mostly 0·5 to 0·7 in.	$4\frac{3}{8}$*d.*[3]
16	Do. . .	1916	36·6 per cent., 5·7 grams per 100 seeds	Harsh, little lustre, pale cream colour, free from stains	Small, covered with greenish-brown fuzz	Fair	0·6 to 0·9 in., mostly 0·7 to 0·8 in.	7*d.*[4]
17	"Berar Jari"	1913	35·8 per cent., 3·37 grams per 100 seeds	Clean, fairly fine, rather harsh, moderate lustre, pale cream colour, almost free from stains	Small, mostly covered with short greenish fuzz, some with white fuzz of medium length	Fairly good	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	$6\frac{1}{8}$*d.* (nominal).[1]

[1] *With "middling" American at* 6·81*d. per lb., "fine" Broach at* $6\frac{5}{8}$*d. per lb., and "fine" Bengals at* $5\frac{3}{4}$*d. per lb.* (*March* 1913).

[2] *With "middling" American* (*April "futures"*) *at* 6·9*d. per lb.* (*May* 1914).

[3] *With "middling" American* (*June "futures"*) *at* 5·25*d. per lb.* (*July* 1915).

[4] *With "middling" American at* 8·25*d. per lb., "good" Bengals at* 5·63*d. per lb., "good" Oomra No.* 1 *at* 6·10*d. per lb., and "good" Broach at* 7·60*d. per lb.* (*July* 1916).

TABLE II—*continued*

RESULTS OF THE EXAMINATION OF 44 SAMPLES OF COTTON GROWN AT THE GOVERNMENT EXPERIMENTAL FARM, AKOLA, BERAR, CENTRAL PROVINCES, RECEIVED IN 1913, 1914, 1915 AND 1916

No.	Variety.	Year.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value. *Per lb.*
18	"Berar Jari"	1914	38·4 per cent., 3·59 grams per 100 seeds	Clean, harsh, moderately lustrous, cream colour, practically free from stains	Small, covered with short brown or greyish fuzz	Fair	0·5 to 0·9 in., mostly 0·5 to 0·7 in.	$5\frac{7}{8}$*d.* (nominal).[2]
19	Do. . .	1915	32·2 per cent., 2·54 grams per 100 seeds	Clean, rather harsh, moderately lustrous, pale cream colour, free from stains	Small, mostly covered with long white fuzz; a few brownish seeds without fuzz also present	Somewhat irregular, fair on the whole	Somewhat irregular, 0·6 to 1·1 in., mostly 0·7 to 0·9 in.	$4\frac{1}{2}$*d.*[3]
20	Do. . .	1916	35·0 per cent., 3·2 grams per 100 seeds	Clean, fairly soft, fair lustre, pale cream colour	Mostly very small, with greenish-grey or brownish-grey fuzz; a small proportion fairly large and covered with white fuzz	Fair	0·6 to 1·2 in., mostly 0·8 to 1·0 in.	6*d.* to $6\frac{1}{2}$*d.* (nominal).[4]
21	"Saugor Jari"	1913	30·1 per cent., 2·25 grams per 100 seeds	Clean, fairly fine, rather harsh, moderate lustre, pale cream colour, almost free from stains	Small, covered with short greenish or brownish fuzz	Good	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	6*d.* (nominal).[1]
22	Do. . .	1914	32·7 per cent., 2·37 grams per 100 seeds	Clean, harsh, moderately lustrous, cream colour with occasional small brownish stains	Small, covered with short brownish or greyish fuzz	Fair. A small quantity of weak, immature fibre was present	0·5 to 1·0 in., mostly 0·6 to 0·8 in.	$5\frac{3}{4}$*d.* (nominal).[2]
23	Do. . .	1915	33·0 per cent., 2·15 grams per 100 seeds	Clean, fairly soft, moderately lustrous, pale cream colour, free from stains	Small, covered with short greyish-brown fuzz	Good	0·7 to 1·0 in., mostly 0·7 to 0·9 in.	$4\frac{5}{8}$*d.*[3]

24	Do. . .	1916	31·4 per cent., 2·5 grams per 100 seeds	Clean, rather harsh, little lustre, pale cream colour	Small, covered with short greyish fuzz	Fair	0·6 to 0·9 in., mostly about 0·8 in.	6d. to $6\frac{1}{4}d$.[4]
25	"Bani III"	1913	28·9 per cent., 2·29 grams per 100 seeds	Clean, fine, soft, lustrous, cream colour, free from stains	Small, covered with short grey, brown or greenish-brown fuzz	Good. A little weak, undeveloped fibre was present	0·8 to 1·2 in., mostly 0·9 to 1·1 in.	$6\frac{1}{2}d$. (nominal).[1]
26	Do. . .	1914	29·5 per cent., 1·92 grams per 100 seeds	Clean, fairly soft, moderately lustrous, cream colour, with a few brownish stains	Small, some covered with grey fuzz of medium length, others with short brown fuzz	Good. A small quantity of weak, immature fibre was present	Somewhat irregular; 0·4 to 1·2 in., mostly 0·7 to 0·9 in.	$6\frac{1}{8}d$. (nominal).[2]
27	Do. . .	1915	27·6 per cent., 1·67 grams per 100 seeds	Clean, soft, fairly lustrous, cream colour, free from stains	Very small, covered with short greyish-brown fuzz	Good	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	$5\frac{3}{4}d$.[3]
28	Do. . .	1916	25·0 per cent., 2·0 grams per 100 seeds	Clean, fairly soft and lustrous, almost white, free from stains	Small, covered with short greyish fuzz	Good	0·8 to 1·2 in., mostly 0·9 to 1·1 in.	8·65d. to 8·75d.[4]
29	"Buri I" .	1913	35·1 per cent., 3·3 grams per 100 seeds	Clean, fairly fine, rather harsh, fairly good lustre, pale cream colour, almost free from stains	Mostly small, covered with short greenish-brown fuzz; some of medium size with fairly long white fuzz, and others dark brown and clean; some undeveloped seeds were also present	Good, rather irregular	0·6 to 1·1 in., mostly 0·7 to 0·9 in.	$6\frac{3}{8}d$. (nominal).[1]

[1] *With "middling" American at* 6·81*d. per lb., "fine" Broach at* $6\frac{5}{8}d$. *per lb., and "fine" Bengals at* $5\frac{3}{4}d$. *per lb.* (*March* 1913).

[2] *With "middling" American* (*April "futures"*) *at* 6·9*d. per lb.* (*May* 1914).

[3] *With "middling" American* (*June "futures"*) *at* 5·25*d. per lb.* (*July* 1915).

[4] *With "middling" American at* 8·25*d. per lb., "good" Bengals at* 5·63*d. per lb., "good" Oomra No.* 1 *at* 6·10*d. per lb., and "good" Broach at* 7·60*d. per lb.* (*July* 1916).

TABLE II—*continued*

RESULTS OF THE EXAMINATION OF 44 SAMPLES OF COTTON GROWN AT THE GOVERNMENT EXPERIMENTAL FARM, AKOLA, BERAR, CENTRAL PROVINCES, RECEIVED IN 1913, 1914, 1915 AND 1916

No.	Variety.	Year.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value. *Per lb.*
30	"Buri I"	1914	30·7 per cent., 3·89 grams per 100 seeds	Clean, rather harsh, fairly lustrous; cream colour, practically free from stains	Medium size, covered with rather long greyish or greenish fuzz	Fair	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	6¼*d.* (nominal).[2]
31	Do.	1915	31·1 per cent., 3·80 grams per 100 seeds	Clean, fairly soft, moderately lustrous, pale cream colour, practically free from stains	Large, covered with long greyish or brownish fuzz	Fairly good	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	5½*d.*[3]
32	Do.	1916	30·4 per cent., 4·16 grams per 100 seeds	Clean, fairly soft and lustrous, nearly white	Moderate size, mostly covered with long white fuzz, a few with greyish fuzz	Poor	0·8 to 1·1 in., mostly 0·9 to 1·0 in.	6¾*d.* (nominal).[4]
33	"Buri II"	1913	31·7 per cent., 4·1 grams per 100 seeds	Clean, fairly fine and soft, moderate lustre, pale cream colour, practically free from stains	Medium size, covered with fairly long white or greenish fuzz; a few clean or almost clean dark brown seeds also present.	Fair, rather irregular	0·8 to 1·3 in., mostly 0·9 to 1·1 in.	6½*d.* (nominal).[1]
34	Do.	1914	32·5 per cent., 3·87 grams per 100 seeds	Clean, fairly soft and lustrous, cream colour, a few small yellowish-brown stains	Medium size, covered with long white or brownish fuzz	Fairly good	0·5 to 1·2 in., mostly 0·8 to 1·0 in.	6¼*d.* (nominal).[2]
35	"Bani x Deshi Lahore"	1913	35·1 per cent., 3·17 grams per 100 seeds	Clean, fairly fine, rather harsh, moderate lustre, pale cream colour, nearly white, almost free from stains	Small, covered with short grey, brownish or greenish fuzz	Fair	0·7 to 1·1 in., mostly 0·8 to 1·0 in.	5⅞*d.* (nominal).[1]
36	Do.	1914	37·5 per cent., 3·00 grams per 100 seeds	Clean, rather harsh, moderately lustrous, pale cream colour, almost free from stains	Small, covered with white or brownish fuzz of medium length	Fairly good	0·7 to 1·2 in., mostly 0·8 to 1·0 in.	6*d.* (nominal).[2]

37	Do. . .	1915	36·4 per cent., 3·06 grams per 100 seeds	Clean, rather harsh, moderately lustrous, very pale cream colour (almost white), free from stains	Small, covered with short greenish or brownish-grey fuzz	Fairly good	0·5 to 1·0 in., mostly 0·7 to 0·9 in.	4¾d.[3]
38	Do. . .	1916	35·2 per cent., 2·9 grams per 100 seeds	Clean, fairly soft, little lustre, white	Small, covered with short greenish or brownish fuzz	Uneven, good on the whole	0·7 to 1·0 in., mostly about 0·8 in.	7¾d.[4]
39	"Bani x Rosea"	1914	31·9 per cent., 2·69 grams per 100 seeds	Clean, fairly soft and lustrous, pale cream colour and free from stains	Small, covered with short greyish-brown fuzz	Good	0·7 to 1·1 in., mostly 0·8 to 1·0 in.	5⅞d. (nominal).[2]
40	Do. . .	1916	35·0 per cent., 2·7 grams per 100 seeds	Clean, fairly soft, little lustre, white, free from stains	Small, covered with short light brownish or greyish fuzz	Fair	0·7 to 1·1 in., mostly about 0·9 in.	6⅝d.[4]
41	"Bani x Mathio"	1914	31·0 per cent., 1·83 grams per 100 seeds	Clean, fairly soft and lustrous, pale cream colour, practically free from stains	Small, covered with short greyish, greenish or brownish fuzz	Good	0·5 to 1·2 in., mostly 0·7 to 0·9 in.	5¼d. (nominal).[2]
42	Do. . .	1916	28·6 per cent., 2·37 grams per 100 seeds	Soft, fairly lustrous, almost white; some immature cotton present	Small, covered with short greyish or brownish fuzz	Uneven, good on the whole	0·7 to 1·1 in., mostly 0·8 to 0·9 in.	6¾d.[4]
43	"Cultivator's Jari"	1914	36·5 per cent., 3·32 grams per 100 seeds	Clean, rather harsh, moderately lustrous, cream colour, practically free from stains	Small, covered with short greyish, brownish or greenish fuzz	Fairly good	0·6 to 1·1 in., mostly 0·7 to 0·9 in.	5⅞d. (nominal)[2]
44	"K. 7" .	1916	34·0 per cent., 3·1 grams per 100 seeds	Clean, rather harsh, little lustre, pale cream in colour, free from stains	Small, covered with short greenish-grey or brownish-grey fuzz	Fairly good	0·7 to 0·9 in., mostly about 0·8 in.	6½d.[4]

[1] *With "middling" American at* 6·81*d. per lb., "fine" Broach at* 6⅝*d. per lb., and "fine" Bengals at* 5¾*d. per lb.* (*March* 1913).
[2] *With "middling" American* (*April "futures"*) *at* 6·9*d. per lb.* (*May* 1914).
[3] *With "middling" American* (*June "futures"*) *at* 5·25*d. per lb.* (*July* 1915).
[4] *With "middling" American at* 8·25*d. per lb., "good" Bengals at* 5·63*d. per lb., "good" Oomra No.* 1 *at* 6·10*d. per lb., and "good" Broach at* 7·60*d. per lb.* (*July* 1916).

TABLE III

RESULTS OF THE EXAMINATION OF 9 SAMPLES OF COTTON FROM THE GOVERNMENT EXPERIMENTAL FARM, SINDEWAHI, CENTRAL PROVINCES, RECEIVED IN 1915, 1916

No.	Variety.	Year.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value. *Per lb.*
1	"Cambodia"	1915	33·5 per cent., 4·29 grams per 100 seeds	Fairly clean, rather harsh, moderate lustre, cream colour, occasional very small yellow stains	Large, covered with long white fuzz	Irregular, mostly rather poor	Irregular, 0·7 to 1·3 in., mostly 0·9 to 1·1 in.	5¾*d.*[1]
2	Do. . .	1916	33 per cent., 3·4 grams per 100 seeds	Clean, fairly soft, moderate lustre, cream-coloured	Moderate size, mostly covered with rather long greyish-brown fuzz; a small proportion covered with green fuzz	Fairly good	0·6 to 1·2 in., mostly about 0·9 to 1·0 in.	7·75*d.*[2]
3	"Rosea" .	1915	38·2 per cent., 3·55 grams per 100 seeds	Fairly clean, harsh, poor lustre, cream colour, many large yellowish or reddish stains	Small, covered with short brownish fuzz	Irregular, varying from fairly good to poor	0·5 to 0·9 in., mostly 0·5 to 0·7 in.	4¼*d.* (nominal).[1]
4	Do. . .	1916	37·8 per cent., 3·6 grams per 100 seeds	Rather harsh, fairly lustrous, cream tint, almost white, practically free from immature cotton and showed few stains	Small, covered with short brown fuzz, tuft of long white fuzz at pointed end	Good	0·5 to 0·7 in.	5·50*d.*[2]

5	"Buri" .	1916	30 per cent., 3·26 grams per 100 seeds	Clean, fairly soft, moderately lustrous, almost white, free from stains and immature fibre	Moderate size, mostly covered with long brownish fuzz; a small proportion covered with green fuzz	Rather uneven, good on the whole	0·5 to 1·1 in., mostly 0·7 to 0·8 in.	7·00*d.*[2]
6	"Bani x Rosea 1145"	1916	34·6 per cent., 3·33 grams per 100 seeds	Clean, rather harsh, but less so than No. 4, little lustre, white, free from stains and immature fibre	Rather small, covered with very short light brown fuzz	Good	0·6 to 0·8 in.	6·75*d.*[2]
7	"Bani x Deshi Lahore" .	1915	—	Fairly clean, rather harsh, lustreless, cream colour, many large brownish stains	—	Rather poor	0·7 to 1·1 in., mostly 0·8 to 0·9 in.	5¼*d.*[1]
8	Do. . .	1916	33·8 per cent., 2·92 grams per 100 seeds	Clean, rather harsh, fairly lustrous, white, free from stains and immature fibre	Rather small, covered with short greenish or brown fuzz	Fairly good	0·5 to 1·1 in., mostly 0·7 to 0·8 in.	7·25*d.*[2]
9	"K.7" .	1916	32·6 per cent., 2·06 grams per 100 seeds	Clean, rather harsh, little lustre, white, free from stains and immature fibre	Very small, covered with short light brown or light greenish-grey fuzz	Uneven, good on the whole	0·6 to 0·9 in., mostly 0·7 to 0·8 in.	6*d.* (nominal).[2]

[1] *With "middling" American (May to June "futures") at 5·63d. per lb. (April* 1915).
[2] *With "middling" American (April "futures") at 7·50d. per lb. (April* 1916).

TABLE IV

RESULTS OF THE EXAMINATION OF DHARWAR AMERICAN COTTONS GROWN ON THE LYALLPUR EXPERIMENTAL FARM, PUNJAB

No.	Variety.	Description of lint.	Strength.	Length of fibres.	Commercial value.[1] *Per lb.*
1	"7 F."	Clean, slightly "leafy," rather harsh, moderate lustre, pale cream colour, free from stains	Fair	0·7 to 1·1 in.; mostly 0·9 to 1·1 in.	6⅜*d.* to 6½*d.*
2	"70 F."	Clean, slightly "leafy," rather harsh, moderate lustre, pale cream colour, several small yellow or brownish stains	Fairly good	0·8 to 1·1 in.; mostly 0·9 to 1·1 in.	6⅛*d.* to 6¼*d.*
3	"72 F."	Clean, slightly "leafy," fairly soft and lustrous, pale cream colour, a few small yellow or brownish stains	Fairly good	0·8 to 1·2 in.; mostly 0·9 to 1·1 in.	6½*d.* to 6¾*d.*
4	"110 F."	Clean, slightly "leafy," fairly soft, moderately lustrous, pale cream colour, several small yellow or brownish stains	Fairly good	0·7 to 1·1 in.; mostly 0·7 to 0·9 in.	6*d.* to 6⅛*d.*
5	"111 F."	Clean, rather harsh, moderate lustre, pale cream colour, a few small yellow or brownish stains. The sample contained many fragments of seed husks	Fair	0·7 to 1·1 in.; mostly 0·8 to 1·0 in.	6*d.*
6	"126 F."	Clean, slightly "leafy," fairly soft, moderate lustre, pale cream colour, practically free from stains	Fairly good	0·7 to 1·1 in.; mostly 0·8 to 1·0 in.	6*d.*
7	"161 F."	Clean, slightly "leafy," fairly soft, moderately lustrous, pale cream colour, a few small yellowish or brownish stains	Fair	0·9 to 1·3 in.; mostly 1·0 to 1·2 in.	6⅜*d.*
8	"168 F."	Clean, slightly "leafy," fairly soft, moderately lustrous, pale cream colour, a few small yellow or brownish stains	Fair	0·9 to 1·2 in.; mostly 1·0 to 1·[illegible] in.	6½*d.*
9	"179 F."	Clean, slightly "leafy," soft, fairly lustrous, pale cream colour, several small yellow or brown stains	Fairly good	0·7 to 1·2 in.; mostly 0·9 to 1·[illegible] in.	6⅛*d.* to 6¼*d.*
10	"199 F."	Clean, slightly "leafy," rather harsh, fairly lustrous, pale cream colour (almost white), several small yellow or brownish stains	Fair	Rather irregular; 0·7 to 1·2 in.; mostly 0·9 to 1·1 in.	6¼*d.*

11	"112 F."	Clean, slightly "leafy," rather harsh, fairly lustrous, pale cream colour (almost white), free from stains	Good	0·8 to 1·2 in.; mostly 0·8 to 1·0 in.	$6\frac{1}{4}d.$
12	"211 F."	Clean, rather harsh, moderately lustrous, pale cream colour, several small yellow or brownish stains. Many pieces of broken seed husk were present	Fair	0·8 to 1·1 in.; mostly 0·8 to 1·0 in.	$5\frac{7}{8}d.$
13	"226 F."	Clean, slightly "leafy," harsh, moderately lustrous, cream colour, several small yellow or brownish stains	Fairly good	0·6 to 1·0 in.; mostly 0·7 to 0·9 in.	$5\frac{7}{8}d.$
14	"232 F."	Clean, slightly "leafy," harsh, moderately lustrous, cream colour, a large number of small yellow or brownish stains	Good	Rather irregular; 0·6 to 1·2 in.; mostly 0·8 to 1·0 in.	$5\frac{7}{8}d.$ to $6d.$
15	"233 F."	Clean, slightly "leafy," rather harsh, moderately lustrous, pale cream colour (almost white), several small yellow or brownish stains	Good	0·8 to 1·2 in.; mostly 0·8 to 1·0 in.	$6\frac{1}{8}d.$ to $6\frac{3}{16}d.$
16	"275 F."	Clean, rather harsh, moderately lustrous, pale cream colour, a few small yellow or brownish stains. Several seeds were present in the sample	Rather poor	0·7 to 1·0 in.; mostly 0·8 to 1·0 in.	$6d.$
17	"280 F. H. No. 2"	Clean, fairly soft, moderately lustrous, pale cream colour, a few small yellow or brownish stains	Fairly good	0·8 to 1·3 in.; mostly 1·0 to 1·2 in.	$6\frac{5}{8}d.$
18	"281 F. H. No. 1"	Clean, fairly soft and lustrous, pale cream colour, several small yellow or brownish stains	Good	Irregular; 0·9 to 1·6 in.; mostly over 1·0 in.	$6\frac{1}{2}d.$ to $6\frac{5}{8}d.$
19	"282 F."	Clean, slightly "leafy," fairly soft and lustrous, pale cream colour (almost white), nearly free from stains	Fair	0·9 to 1·5 in.; mostly 1·0 to 1·2 in.	$6\frac{5}{8}d.$
20	"266 F."	Clean, slightly "leafy," rather harsh, moderately lustrous, pale cream colour (almost white), several small yellow or brownish stains	Fair	0·7 to 1·0 in.; mostly 0·7 to 0·9 in.	$6\frac{1}{8}d.$ to $6\frac{1}{4}d.$

[1] *With "good" Tinnevelly at* $6\frac{1}{16}d.$ *per lb. (nominal), "fine" Broach at* $6\frac{1}{4}d.$ *per lb. (nominal), and "middling" American at* 6·69*d. per lb.* (*June* 1913).

Punjab

Experiments have been conducted for a number of years at the Lyallpur Experiment Farm with American, Egyptian, Cambodia, perennial and other types of exotic cottons, but the only kinds which have proved successful are American varieties. American cotton has now become acclimatised, and in 1914 70,000 acres were planted with this type. It gives a somewhat better yield, and realises higher prices than the indigenous ("desi") cotton. The American cotton grown by the natives, however, consists of a mixture of varieties, and is often somewhat mixed with the "desi" kinds, so that the lint is not uniform and cannot command the best prices. A large number of selected strains have been isolated at the Lyallpur Farm from the acclimatised American cottons, and some of these, in particular that known as 4F, have proved much superior to the unselected American cotton, both in regard to quality and yield of lint and to resistance to the attacks of insect pests. In 1914–15, 2,000 acres of the 4F selection were grown in the Lyallpur colony, and it is hoped that in time the selected strains will replace entirely the ordinary American cotton of the district.

Samples of the lint of twenty selected strains of American cotton, grown at the Lyallpur Farm, were sent to the Imperial Institute in 1913. The results of their examination are given in Table IV (pp. 164, 165).

According to the *Rep. Dept. Agric., Punjab*, 1912–13, the samples were grown on very sandy soil, and to this is attributed the irregularity in length exhibited by some of the cottons. The same selections grown on good land in 1913–14 and 1914–15 did not exhibit this irregularity, but in 1915–16, when they were grown on the same land as that used in 1912–13, it was again apparent.

All the samples examined at the Imperial Institute were of fair quality and represented cottons which would be saleable in the United Kingdom. Samples Nos. 7, 8 and 17 had the longest average staple, and were valued respectively at 6⅝*d.*, 6½*d.* and 6⅝*d.* per lb. Sample No. 18 was also of good length but was rather irregular (0·9 to 1·6 in.), and

was valued at $6\frac{1}{2}d.$ to $6\frac{5}{8}d.$ per lb. Sample No. 3, which was valued at the highest price (viz. $6\frac{1}{2}d.$ to $6\frac{3}{4}d.$ per lb.), much resembled Nos. 1 and 2, but was somewhat softer.

Samples 10 and 11 were a little superior in colour to the other samples, but were rather harsh for American cotton.

The valuations given for these cottons are for commercial quantities of not less than 1 ton of lint equal in quality to the samples. In this connection it must be borne in mind that the price depends not only on the intrinsic quality of the cotton, but also on its condition, such as freedom from stains, absence of "leaf," seed, etc.

The ordinary ("desi") cotton grown in the Punjab consists of a mixture of varieties of at least three species of Gossypium, viz. *G. sanguineum*, *G. indicum* and *G. neglectum.* Selection experiments have been conducted at the Lyallpur Experiment Farm and the main types have been isolated, but so far the work has not given such satisfactory results as that conducted with American varieties. A form of *G. sanguineum*, however, which gives good yields of short, rough cotton, has been grown on a large scale at Lyallpur, and the seed distributed to cultivators; about 1,450 acres were planted with this variety in the Lyallpur district in 1914. In 1913 eight samples of seed-cotton of different indigenous varieties, grown at Lyallpur, were received for examination at the Imperial Institute. They were as follows:

No. 1. *G. sanguineum.*—Broad leaf type, red flower.
No. 2. *G. sanguineum.*—Narrow leaf type, red flower.
No. 3. *G. sanguineum.*—Broad leaf type, pink flower.
No. 4. *G. sanguineum.*—Narrow leaf type, pink flower.
No. 5. *G. indicum.*—Yellow flower.
No. 6. *G. indicum.*—White flower.
No. 7. *G. neglectum.*—Yellow flower.
No. 8. *G. neglectum.*—White flower.

The yield of lint, on ginning, is shown in the following table:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Per cent.	30·5	26·2	31·8	33·8	29·8	36·8	30·0	34·6
Per 100 seeds, *grams*	2·17	1·82	2·22	2·10	1·93	2·80	2·13	2·11

The eight samples were very similar to one another. The lint was clean, rather harsh and coarse, of moderate to fairly good lustre, of pale cream colour (almost white), and free, or almost free, from stains. The seeds in each case were small and covered with short brownish or brownish-white fuzz. The cottons were all of satisfactory strength, and the different samples varied in length from 0·5 to 0·9 in. up to 0·7 to 1·1 in., most of the fibres being about $\frac{3}{4}$ in. long.

The experts to whom the samples were submitted for valuation reported that the ginned cotton would be worth from $5\frac{3}{4}d.$ to $6d.$ per lb. (May 1913), with "fine" Bengals at $5\frac{9}{16}d.$ per lb. If the fibre had been a little longer and less rough, the value would have been increased by $\frac{1}{2}d.$ per lb.

Two further samples, representing the ordinary Indian and American cottons, respectively, as grown by the native farmer, were also received in 1913.

No. 1. "Indian Cotton. Ordinary farmer's sample (Zamindari)." — Fairly clean, "leafy," harsh, moderately lustrous cotton, of cream colour with many small brownish or yellowish stains. It was of good strength, but irregular in length, varying from 0·5 to 1·1 in., being mostly from 0·7 to 0·9 in.

This cotton was of poor quality, and was valued at $5\frac{1}{4}d.$ per lb., with "good" Tinnevelly at $6\frac{1}{16}d.$ per lb.; "fine" Broach at $6\frac{1}{4}d.$ per lb.; and "middling" American at $6·69d.$ per lb. (August 1913).

No. 2. "American Cotton. Ordinary farmer's sample (Zamindari)."—Fairly clean, rather "leafy," moderately lustrous, somewhat harsh cotton, of cream colour with several small yellow or brownish stains. Many seeds were present in the lint. The strength of the cotton was rather irregular, but on the whole fairly good, though some weak, immature fibres were present. The length of the fibres varied from 0·7 to 1·3 in., but was mostly from 0·9 to 1·1 in.

This cotton was harsher and of poorer quality than the American cottons grown at the Lyallpur Experiment Farm (see p. 166). It was valued at from $5\frac{3}{4}d.$ to $5\frac{7}{8}d.$ per lb. on the same date as the preceding sample.

BOMBAY

An account of the experiments with long-stapled cottons which have been conducted in Sind, Bombay Presidency, was given in this BULLETIN (1911, 9, 217), together with the results of examination of samples of seed-cotton grown during 1910-11. A further series of nine samples grown on the Mirpurkhas Farm, Sind, in 1912-13, has since been examined at the Imperial Institute, and the results are shown in Table V (pp. 170-71).

The varieties grown at Mirpurkhas include "Mitafifi" (Egyptian), "Sindhi" (indigenous) and several Improved American Upland cottons. The yields of seed-cotton per acre obtained during the years 1912-13, 1913-14 and 1914-15 were as follows:

Variety.	1912-13. *lb.*	1913-14. *lb.*	1914-15. *lb.*
Mitafifi	509-594	458	509
Sindhi	904-1,710	771-914	461-1,285
Texas Big Boll	665-719	282	798
Triumph	1,096	223-616	753
Peterkin	532	120	716
Toole's	374	306	847
Allen's Long Staple	839	295	566
Griffin	703	539	779
Black Rattler	642	204	833

It will be seen that of the American cottons, "Triumph" has, on the whole, given the best results, and 40 tons of seed of this variety have been imported and distributed among zamindars in Upper Sind and the Jamrao tract.

The cottons grown in 1912-13 which were examined at the Imperial Institute were in general of very satisfactory quality and would be readily saleable. In some cases they exhibited a little irregularity in length or strength, but these defects would probably be overcome by acclimatisation and systematic selection of seed from the best plants in the field.

In most particulars the samples resembled the series previously examined (*loc. cit.*), but it may be of interest to

TABLE V

RESULTS OF THE EXAMINATION OF 9 SAMPLES OF COTTON GROWN ON THE MIRPURKHAS FARM, SIND, IN 1912–13

No.	Variety.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value. *Per lb.*
1	"Mitafifi"	34·4 per cent., 5·17 grams per 100 seeds	Clean, soft, fine, fairly good lustre, pale reddish-brown colour, a few small yellow or brownish stains	Small, smooth, chocolate colour; a small tuft of short bright green fuzz at one or both ends	Irregular. A large proportion of weak, immature fibre present	Irregular; 0·7 to 1·6 in., mostly 1·2 to 1·4 in.	8·50*d.*, with "fully good fair" brown Egyptian at 10·05*d.* per lb.
2	"Sindhi"	38·6 per cent., 3·49 grams per 100 seeds	Clean, harsh, coarse, moderate lustre, cream colour, free from stains	Small, covered with short greyish-brown fuzz	Good	0·7 to 1·0 in., mostly 0·7 to 0·9 in.	6·00*d.* (nominal), with "fine" machine-ginned Bengals at $5\frac{7}{8}$*d.* per lb.
3	"Texas Big Boll"	36·4 per cent., 6·51 grams per 100 seeds	Clean, soft, fine, lustrous, cream colour, free from stains	Rather large, covered with long white or brownish fuzz	Fairly good	0·9 to 1·5 in., mostly 1·1 to 1·3 in.	7·30*d.*[1] "Fully good middling" grade.
4	"Triumph"	33·0 per cent., 3·92 grams per 100 seeds	Clean, soft, fine, lustrous, cream colour, free from stains	Medium size, covered with fairly long white, greenish or brownish fuzz	Fairly good	0·8 to 1·3 in., mostly 0·9 to 1·1 in.	7·20*d.*[1] "Strict good middling" grade.

5	"Peterkin"	35·3 per cent., 5·16 grams per 100 seeds	Clean, fairly soft, fine, lustrous, cream colour, free from stains	Rather small to medium in size, mostly covered with rather long white, brownish or greenish fuzz; some smooth, dark brown seeds without fuzz also present	Good	0·8 to 1·4 in., mostly 0·9 to 1·1 in.	7·10*d.*[1] "Strict good middling" grade.
6	"Toole's"	34·4 per cent., 4·25 grams per 100 seeds	Clean, soft, fairly fine, lustrous, cream colour, almost free from stains	Rather small or medium-sized, mostly covered with fairly long white, greenish or brownish fuzz; a few smooth dark chocolate-coloured seeds without fuzz also present	Rather irregular, mostly weak	0·8 to 1·3 in., mostly 0·9 to 1·1 in.	7·10*d.* to 7·30*d.*[1] "Fully good middling" grade.
7	"Allen's Long Staple"	29·0 per cent., 3·79 grams per 100 seeds	Clean, soft, fine, lustrous, cream colour, practically free from stains	Medium size, mostly covered with fairly long white, greenish or brownish fuzz; a few almost smooth seeds also present	Good, but somewhat irregular	1·0 to 1·8 in., mostly 1·2 to 1·4 in.	8·20*d.* per lb.[1]
8	"Griffin"	29·5 per cent., 3·58 grams per 100 seeds	Clean, soft, fine, lustrous, cream colour, a few small yellow stains	Medium size, covered with fairly long white, brownish or greenish fuzz; a few small dark brown seeds without fuzz also present	Fair. Some weak, immature fibre was present	0·9 to 1·4 in., mostly 1·1 to 1·3 in.	7·50*d.*[1] "Strict good middling grade.
9	"Black Rattler"	30·5 per cent., 3·54 grams per 100 seeds	Clean, soft, fine, lustrous, cream colour, free from stains	Medium size, covered with varying amounts of fairly long white, greenish or brownish fuzz; a few smooth seeds without fuzz also present	Good	Irregular; 0·8 to 1·4 in.	7·50*d.*[1] "Strict good middling" grade.

[1] *With "fully good middling" American at 7·25d. per lb. and "middling" American at 6·96d. per lb. (April 1913).*

summarise the chief points in which some of those grown in 1912–13 differed from the earlier ones:

"Triumph" . . .	Rather better strength.
"Peterkin" . . .	Decidedly stronger.
"Toole's" . . .	Shorter and of more irregular strength.
"Allen's Long Staple"	Longer and free from the short, coarse fibre which marred the earlier sample.
"Griffin" . . .	Weaker and shorter.
"Black Rattler" . .	Rather more irregular in length.

United Provinces

Four samples of cotton grown experimentally in the Eastern Circle, United Provinces, were received at the Imperial Institute in May 1915. The results of their examination are shown in Table VI.

These cottons were evidently not regarded by the trade as suitable substitutes for the American Upland cotton which forms the bulk of the raw material of the Lancashire mills, for on the date on which the present samples were valued at 4·25*d.* to 4·50*d.* per lb., "middling" American was quoted at 7·15*d.* per lb. In the case of the "Buri" cotton, certain samples received previously at the Imperial Institute were somewhat longer and therefore more valuable than sample No. 1, being mostly about 0·9 to 1·1 in., and a specimen of this length which had been grown at Akola was valued at 5½*d.* with "middling" American at 5·25*d.* per lb.; whilst another from the same farm and of the same length was valued at 6¼*d.*, with "middling" American at 6·9*d.* per lb. (see p. 160). It seemed desirable therefore that attention should be devoted in the United Provinces to improving the length of this cotton by selection methods.

All the cottons would be quite suitable for use in mills where the machinery is adapted for spinning short staples.

Burma

The indigenous cottons of Burma are on the whole of poor quality, but some of the strains have a fairly long staple and are equal in value to the best Indian cottons and only a little inferior to "middling" American. The chief cotton-growing districts are Meiktila, Myingyan,

TABLE VI

RESULTS OF THE EXAMINATION OF 4 SAMPLES OF COTTON FROM THE EASTERN CIRCLE, UNITED PROVINCES, RECEIVED IN 1915

No.	Variety.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value.[1] *Per lb.*
1	"Buri"	31·8 per cent., 3·4 grams per 100 seeds	Fairly clean and soft, moderately lustrous, cream colour, some fair-sized yellowish-brown stains	Medium size, covered with varying quantities of grey, green or brown fuzz; a few black, almost smooth seeds were also present	Fair, rather irregular	0·7 to 1·0 in., mostly 0·8 to 0·9 in.	4·5*d.*
2	"Yellow flower"	34·6 per cent., 2·56 grams per 100 seeds	Fairly clean, somewhat harsh, moderately lustrous, cream colour, a few small yellowish-brown stains	Small, covered with short greyish fuzz; many had been attacked by insects	Fair	0·6 to 1·0 in., mostly 0·7 to 0·8 in.	4·25*d.*
3	"Varhadi"	36·4 per cent., 3·29 grams per 100 seeds	Fairly clean, somewhat harsh, moderately lustrous, cream colour, some medium-sized yellow and brown stains	Rather small, covered with short greyish or brownish fuzz; a large number had been attacked by insects	Fairly good	0·6 to 1·1 in., mostly 0·7 to 0·9 in.	4·25*d.*
4	"Cutchica"	35·3 per cent., 3·29 grams per 100 seeds	Fairly clean, somewhat harsh, moderately lustrous, cream colour, with some medium-sized yellowish-brown stains	Small, covered with short greyish fuzz; many had been attacked by insects	Fairly good	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	4·25*d.*

[1] *With "fully good fair" Sind and Bengal at 4·68d. and "fully good fair" Broach at 6·3d. per lb.*

Sagaing, Lower Chindwin and Thayetmyo. The most widely cultivated variety in the dry, central tracts of Burma is known as "wa-galè" or "wa-pyu," and this supplies more than three-quarters of the Burmese cotton of commerce; an early maturing form of this variety is known as "wa-yin." "Wa-ni," a variety which produces a red fibre, is sparingly cultivated for local consumption where "wa-galè" is grown, and often mixed with the latter. A perennial cotton ("wa-gyi"), bearing white fibre, is grown to a small extent in Myingyan, Thayetmyo and Minbu, and a form of Pernambuco or kidney cotton, known as "thinbaw-wa," is also cultivated, chiefly as a field crop in the Amherst District. Single plant selections giving specially high ginning yields have been isolated from the "wa-gyi" and "wa-galè" races, and are being cultivated experimentally. Experiments are also being conducted with Cambodia cotton obtained from Madras. At Tatkon this variety gave a yield of 1,200 lb. of seed-cotton per acre in 1912–13. It is superior to the indigenous varieties, and its cultivation is being encouraged in a number of districts.

Two specimens of Cambodia cotton grown on a rubber estate at Myanaung, Lower Burma, and two grown at Tatkon, Upper Burma, were received at the Imperial Institute in 1913, together with four samples of native cottons and one of "kidney" cotton. The results of their examination are given in Table VII (pp. 175, 176).

The first sample of Cambodia cotton grown at Myanaung was of fairly good quality but was somewhat lacking in strength; the second sample was poorer in quality, its value being considerably diminished by stains and by the presence of weak, immature fibres. The "first-class" Cambodia cotton grown at Tatkon was of fairly good quality, but in this case also its value was diminished by stains and the presence of immature fibres; the "second-class" Cambodia from Tatkon was badly stained, and, on the whole, of poor quality. The native cottons were too short in staple to meet with much demand for the Lancashire spinning industry, and there is little or no demand in the United Kingdom for reddish-brown cotton like sample

TABLE VII

RESULTS OF THE EXAMINATION OF 9 SAMPLES OF COTTON FROM BURMA RECEIVED IN 1913

No.	Variety.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value.[1] *Per lb.*
1	"Cambodia" grown at Myanaung	34·8 per cent., 6·63 grams per 100 seeds	Clean, fairly soft, lustrous, cream colour, free from stains	Large size, covered with white or pale brown fuzz	Fair	0·7 to 1·2 in., mostly 1·0 to 1·2 in.	7·00*d.*
2	"Cambodia" grown at Myanaung	32·4 per cent., 3·59 grams per 100 seeds	Clean, soft, irregular lustre, cream to white colour, numerous yellow and brown stains; much immature fibre present	Large size, covered with white; pale brown or green fuzz; more than 25 per cent. were withered or attacked by insects	Very poor, irregular	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	6¼*d.*
3	"First-class Cambodia," grown at Tatkon	35·9 per cent., 5·73 grams per 100 seeds	Clean, soft, lustrous, cream colour, several small yellow stains; a large proportion of immature fibre present	Large size, covered with long white, brownish or greenish fuzz	Poor, irregular	0·9 to 1·3 in., mostly 1·0 to 1·2 in.	6·75*d.*
4	"Second-class Cambodia," grown at Tatkon	36·7 per cent., 4·19 grams per 100 seeds	Rather dusty, soft, moderate lustre, cream colour, a large number of small yellowish-brown stains; a large proportion of immature fibre present	Large size, covered with long white, brownish or greenish fuzz; many withered or attacked by insects	Very poor	0·7 to 1·2 in., mostly 0·9 to 1·1 in.	5½*d.*

[1] *At the date of valuation (June* 1913) *"middling" American was quoted at* 6·57*d. per lb., "fine" Bengals at* 5½*d. per lb. and "good" rough Peruvian at* 9¼*d. per lb.*

TABLE VII—*continued*

RESULTS OF THE EXAMINATION OF 9 SAMPLES OF COTTON FROM BURMA RECEIVED IN 1913

No.	Variety.	Yield of lint on ginning.	Description of lint.	Description of seed.	Strength.	Length of fibres.	Commercial value.[1] *Per lb.*
5	"Wa-galè" or "Wa-pyu"	34·7 per cent., 3·12 grams per 100 seeds	Clean, rather harsh, lustrous, pale cream colour, free from stains	Small, covered with short brownish-grey or greenish-grey fuzz	Good	0·6 to 1·0 in., mostly 0·7 to 0·9 in.	5·75*d.*
6	"Wa-yin"	39·8 per cent., 3·08 grams per 100 seeds	Clean, rather harsh, moderate lustre, pale cream colour (almost white), several small yellow or brownish stains	Small, covered with fairly short brownish-white fuzz	Good	0·6 to 0·9 in., mostly 0·7 to 0·9 in.	5¼*d.*
7	"Wa-ni"	34·5 per cent., 2·84 grams per 100 seeds	Clean, fairly soft, moderate lustre, colour dark reddish-brown to white	Small, covered with short dark brown fuzz	Fairly good, rather irregular	0·6 to 1·2 in., mostly 0·7 to 0·9 in.	5*d.* (nominal).
8	"Wa-gyi"	40·0 per cent., 3·56 grams per 100 seeds	Clean, soft, fairly good lustre, pale cream colour, several small yellow or brownish stains	Small, covered with fairly short white or brownish fuzz	Fair	0·6 to 1·1 in., mostly 0·7 to 0·9 in.	5½*d.* to 5¾*d.*
9	"Thinbaw-wa" ("Kidney" cotton)	23·3 per cent., 4·42 grams per 100 seeds	Clean, moderately rough, lustrous, white, several rather large yellow or brownish stains	Rather large dark brown, without fuzz; the seeds in each lobe of the capsule cling together in a compact cluster of 7 to 10, generally 9, seeds; a few were withered	Fairly good	0·9 to 1·8 in., mostly 1·2 to 1·5 in.	9*d.* to 9¼*d.*

[1] *At the date of valuation (June* 1913) *"middling" American was quoted at* 6·57*d. per lb., "fine" Bengals at* 5½*d. per lb. and "good" rough Peruvian at* 9¼*d. per lb.*

No. 7 ("wa-ni"). The "kidney" cotton ("thinbaw-wa," No. 9) was of good length and useful quality, and would be readily saleable in large quantities in the United Kingdom.

THE LIME FRUIT IN NIGERIA

The lime tree (*Citrus Medica* var. *acida*) occurs in most parts of British West Africa, and in some places has become naturalised. The fruits are utilised to some extent for the preparation of lime-juice to be consumed locally; but, with the exception of 200 gallons of lime-juice, which were exported to the United Kingdom from Sierra Leone in 1913, there appears to be no export trade in the fruit or its products from any of the Colonies and Protectorates in West Africa.

The lime grows well, and is now fairly abundant in some parts of Nigeria, and the possibility of utilising the fruits has recently been investigated by the Government Chemist at Lagos. A specimen of distilled oil of limes prepared in the course of this work was received at the Imperial Institute in July 1916. Subsequently, at the suggestion of the Imperial Institute, some fresh lime fruits and a sample of citrate of lime prepared in Nigeria were forwarded for investigation. The results of examination of these samples are given below.

Fresh Limes

The fruits were pulled in a green state, but fairly fully grown, early in February 1917. They were spread out on a table for three days and then packed. They were picked during the dry season, and it was thought that larger fruits might possibly be obtained in August, when the next crop was due.

The fruits were rather small, measuring from $1\frac{3}{8}$ to $1\frac{5}{8}$ in. in diameter and weighing on the average $1\frac{1}{3}$ oz. each. Two larger fruits, measuring $2\frac{1}{8}$ by 2 in. and weighing 3 oz. each, were also present. The limes were mostly of a light yellow colour, but a few were greenish-yellow. Most of them on arrival showed one or two brown patches on the

rind, but with two exceptions the fruits in the sample were quite sound.

The fruits were examined at the Imperial Institute with the following results, in comparison with figures recorded for two varieties of limes grown at the Botanic Station, Dominica:

	Present sample.	Dominica limes. Spineless.	Ordinary.
Percentage of juice in fruit	57·4	51·3	50·8
Total solids in juice (grams per 100 c.c.)	10·6	11·7	11·1
Citric acid in juice (grams per 100 c.c.)	8·2	9·8	8·9
" " (oz. per gallon)	13·0	15·7 [1]	14·2 [1]
Purity of juice (ratio of acid to total solids)	77·0	83·9	79·5
Percentage of citric acid in entire fruits	4·4	4·8	4·3

[1] *As a rule, the amount of citric acid in the juice of Dominica limes varies from* 12 *to* 14 *oz. per gallon.*

The foregoing results show that these limes from Nigeria are of normal composition.

The limes were submitted to a firm of importers in London, who stated that the quality of the fruit was good, but pointed out that there was only a very limited demand for limes in the United Kingdom. Small supplies at present come from Jamaica and the Canary Islands, but the firm did not consider the demand sufficient to warrant the fruit being grown extensively in Nigeria for the purpose of export to this country.

The firm added that when only a moderate supply of the fruit is available in London prices range round 10*s.* per box of 300 to 400 fruits. As soon as the limited demand is exceeded, however, this figure rapidly falls to about 7*s.* to 8*s.* per box, and in normal times, when supplies have occasionally been heavy, the price has fallen considerably lower.

A second firm regarded the quality of the limes as fair, and stated that the brown patches, although a very common fault with this fruit, detracted from its value. This firm also pointed out that there is not a large market for limes in this country, and that many attempts had been made to popularise the fruit here, but without success.

These Nigerian limes are of good quality and quite suitable for this market. The reports from the firms consulted, however, show that the market for fresh limes in

this country is very limited and that attention should be directed to the export of lime products rather than the fresh fruit.

Distilled Oil of Limes

In preparing this oil ripe fruits were employed, the juice and the skin and pulp being distilled in steam separately and the distillates mixed. The total yield of oil varied in different experiments from 0·13 to 0·21 per cent., the average being 0·17 per cent., expressed on the whole fruit. Oil prepared in this way is not quite comparable with distilled oil of limes of commerce, which is obtained as a by-product in the initial stages of concentrating the raw lime-juice produced by crushing the entire fruit.

The oil received at the Imperial Institute was pale yellow, with a pleasant lemon-like odour. The sample was too small for complete examination, but the physical constants of the oil are shown below, together with those recorded for the Italian oil distilled from *Citrus Limetta* and the West Indian oil distilled from *C. Medica* var. *acida*:

	Present sample.	Italian oil.	West Indian oil.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$.	0·8946	0·8629 to 0·8656	0·865 to 0·868
Optical rotation at 20° C. .	+34° 4′	+34·8° to +45°	+46·6°
Refractive index at 21° C. .	1·4815	—	—

A firm of brokers in London regarded the oil as nominally worth from 7*s.* 6*d.* to 8*s.* per lb. (July 1916), but they pointed out that its pre-war value would probably have fluctuated between 1*s.* 6*d.* and 3*s.* 3*d.* per lb.

The odour of this oil was satisfactory, and the sample appeared to be of good quality.

Citrate of Lime

This sample was prepared from concentrated lime-juice in the ordinary way, *i.e.* by neutralising the juice with chalk, washing the precipitate with hot water and drying. The yield varied from 0·55 to 0·6 oz. of citrate of lime per lb. of fresh fruit. The yield of juice varied from 6 to 7 fluid oz. per lb. of fruit.

The sample, which consisted of a fine white powder with a slight cream tint, was submitted to chemical examination at the Imperial Institute with the following results:

	Per cent.
Moisture (on heating at 100° C.)	4·9
Citric acid	70·6
Calcium carbonate	1·0

Samples of the material were submitted to firms of chemical manufacturers, who reported on it as follows:

(1) One firm stated that the sample was of excellent quality and that they were prepared to purchase similar material at £30 per 6 cwts., discount 1½ per cent., cost and freight to London, on a basis of 64 per cent. of citric acid, the price of shipments containing above or below that quantity to be *pro rata.*

The firm added that they were interested in the question of assisting the citric-acid industry in the British Empire, as at present manufacturers are dependent on Sicily for their raw material. This position is considered unsatisfactory, and the firm state that the development of fresh sources of supply would be welcomed by all the manufacturers concerned.

(2) A second firm stated that if material of the same quality as the sample can be supplied on a commercial scale, they would be glad to purchase considerable quantities if the price could be satisfactorily arranged. At present Sicilian citrate of lime costs about £100 per ton delivered in London.

The present sample represented a high-grade citrate of lime, and material of similar quality would be readily saleable in the United Kingdom at good prices.

TAPIOCA STARCH FROM RHODESIA

Cassava or manioc (from the roots of which tapioca and tapioca starch are prepared) has been grown for several years past at the Agricultural Experimental Station, Salisbury, Rhodesia. The climate appears to be well suited for its cultivation, and 10 to 20 acres are being planted with the

crop at the Government Experiment Farm, Gwebi. The roots have been fed to stock experimentally without ill-effects, and in view also of the existence of a South African market for tapioca and the possibility of exporting cassava starch to Europe, the Director of Agriculture considers that the prospects of this crop for Rhodesia are good.

A small quantity of starch, prepared experimentally from cassava grown at Salisbury, was examined recently at the Imperial Institute. The outer portion of the sample, which was in the form of powder, had been affected by damp, and the inner portion was therefore separated at the Imperial Institute for the purpose of examination. This portion, which was of good white colour with a slight cream tint, showed some specks of extraneous matter, but was on the whole fairly clean.

The separated inner portion of the sample was submitted to chemical examination with the following results:

	Per cent.
Moisture	14·4
Proteins	0·1
Fat	0·15
Starch[1]	82·8
Ash	0·2
Fibre	nil
Matter soluble in water	nil

[1] *Estimated by acid hydrolysis.*

Microscopical examination showed that the sample consisted entirely of tapioca starch granules.

Samples of the material were submitted to importers and dealers, who reported on it as follows:

(1) A firm of importers in Liverpool stated that in their opinion the quality of the starch was good and that the product would have a ready sale provided that the commercial shipments were equal to the sample. They valued the product at about £28 per ton, less 2½ per cent., ex quay Liverpool, war risks included (February 1917).

The firm enquired as to the quantities of the starch available, and stated that they were prepared to make a definite offer for prompt shipment.

(2) A firm of dealers in Dundee considered the sample to represent a medium starch suitable for the starching of

jute yarns and cloth. They valued the starch at from £20 to £25 per ton delivered in Dundee.

The results of examination indicate that the present sample represented a fairly good quality of tapioca starch, which should find a ready market in the United Kingdom if offered in commercial quantities.

A NEW PALM WAX FROM COLOMBIA

A SAMPLE of crude wax obtained from the leaves of *Ceroxylon andicolum*, Humb. & Bonpl., the wax palm of the Andes, was forwarded to the Imperial Institute on behalf of the Colombia Ministry of Agriculture by Mr. M. T. Dawe, Agricultural Adviser to the Colombia Government, in July 1916. The palms, which occur only in western tropical South America, are stated to be exceedingly abundant, but no wax has yet been exported, although it is used in Colombia for making candles.

The sample consisted of fine powdered wax of a pale straw colour, with a small admixture of vegetable matter.

The crude wax as received was submitted to chemical examination at the Imperial Institute with the following results:

	Per cent.
Moisture	1·5
Ash	0·6
Wax	92·0
Dirt (matter insoluble in carbon tetrachloride)	6·5

After purification, and removal of the vegetable matter, the wax was analysed with the following results, which are shown in comparison with those recorded for carnauba and candelilla waxes:

	Present sample.	Carnauba wax.	Candelilla wax.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	1·018	0·990 to 0·999	0·936 to 0·993
Acid value[1]	19·8	4 to 7	12·4 to 21·1
Saponification value[1]	73·7 to 104·4[2]	78·4 to 88·3	35·0 to 104·1
Iodine value . *per cent.*	32·8	13·2 to 13·5	5·2 to 36·8

[1] *Milligrams of potash for 1 gram of wax.*
[2] *The saponification value varies with the conditions of the experiment.*

The purified wax was completely soluble in cold chloroform, carbon tetrachloride, benzene or hot turpentine oil,

but it was not completely soluble in cold alcohol, ether or light petroleum. The melting-point of the purified wax as determined by the open-tube method was 93° C., as compared with 84° C. for carnauba wax and 70 to 72° C. for candelilla wax determined by the same method.

The crude wax-dust would not be readily saleable in this country, and consequently only the purified wax as prepared at the Imperial Institute was submitted to firms of manufacturers and brokers, who reported on it as follows:

(1) The manufacturers were of opinion that the material could replace carnauba wax for many purposes. They stated, however, that its value would be considerably enhanced if it could be bleached, and that this process would also widen its field of possible application in industry.

(2) A second firm stated that the product could certainly be employed industrially, and that its use was simply a question of price. The firm requested that a trial shipment of 2 tons should be forwarded to them for practical trials.

(3) A firm of brokers stated that it was possible they might be able to place supplies of the material on the market as a substitute for carnauba wax. In the first place, however, they asked to be furnished with a sufficient quantity of the product to allow them to submit samples to their customers for trial.

This palm wax is, when purified, similar in character to carnauba wax (*Copernicia cerifera*), which is obtained chiefly from Brazil, and to the candelilla wax (*Euphorbia* sp.) imported from Mexico, with the exception that its melting-point is higher. It should be readily saleable at about the same prices as these waxes, which before the war were selling in the United Kingdom a £5 to £9 per cwt.

As it will be necessary to purify the wax before export, experiments were made at the Imperial Institute with the object of devising a simple method of purification, especially from vegetable débris. It should be possible to effect this purification in Colombia by the following means:

The crude wax-dust, as collected, should be placed in a canvas or calico bag and immersed in boiling water, the

bag being weighted to keep it below the surface; most of the melted wax will then gradually pass through the fabric and rise to the surface of the water. A convenient device is a strong canvas bag, the mouth of which is sewn or tied up after the bag has been filled with the wax-dust. Two sticks, each with a slit in one end, can be fixed easily along the top and bottom of the bag by means of screws. By twisting the sticks pressure is exerted on the canvas bag and causes the melted wax to pass through the canvas.

The water with the layer of wax on top can then be allowed to cool. When quite cold the wax can be removed, powdered, and dried in the sun or in a warm place. The dried powdered wax should finally be melted in a deep vessel over a small fire, or, better, in an oven at about 110° C., care being taken not to heat it longer than is necessary or at a higher temperature than 110° C., as otherwise it will darken in colour.

The re-melted wax on cooling will be found to have deposited a dark layer at the bottom of the cake; this can be cut off and either sold as a lower grade of wax or worked up with the next batch of wax-dust.

The cake thus freed from the dirty material will be ready for shipment.

SPECIAL ARTICLE

THE IMPERIAL INSTITUTE AND THE DOMINIONS ROYAL COMMISSION

THE final report of the Dominions Royal Commission includes certain criticisms of the Imperial Institute and recommendations respecting its future operations.

On the publication of this report the Executive Council of the Imperial Institute appointed a Special Committee to consider these criticisms and recommendations.

The Committee consisted of the Right Hon. LORD ISLINGTON, G.C.M.G., Under-Secretary of State for India, and Chairman of the Executive Council of the Imperial Institute, lately Under-Secretary of State for the Colonies and Governor of New Zealand; the Right Hon. LORD

EMMOTT, G.C.M.G., Director of the War Trade Department, formerly Under-Secretary of State for the Colonies; the Right Hon. LORD BURNHAM; the Hon. Sir THOMAS MACKENZIE, K.C.M.G., High Commissioner for New Zealand; Mr. R. M. KINDERSLEY, Director of the Bank of England and Governor of the Hudson's Bay Company; and Professor WYNDHAM DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute.

This Committee has made the following report, which has been adopted by the Executive Council:

REPORT OF THE SPECIAL COMMITTEE

"The Dominions Royal Commission in their Final Report recommend that the present organisation of the Imperial Institute constituted under the Act of 1916 should be disintegrated, and its principal work distributed among various official and unofficial bodies here and in the Dominions.

"The Commissioners are of opinion that the responsibility for the exhibits of the raw materials of the Empire now shown in the Galleries of the Imperial Institute should be entrusted to the Royal Colonial Institute, that the research hitherto done for the Dominions at the Imperial Institute should in future be conducted in the Dominions, and that research at the Institute should be limited to work for India, the Crown Colonies and the Protectorates.

"It is difficult to discover the basis for these conclusions or the evidence on which they are founded. In the published evidence respecting the Institute taken in the Dominions by the Commission in 1913 and 1914 there is but little criticism of the value of the operations of the Institute, and that little is now out of date. Many of the witnesses testify to its usefulness to the Dominions, and the general tendency of the evidence is to suggest an enlargement rather than a restriction of its operations.

"The Commission was appointed in 1912, and the only evidence taken from the authorities of the Imperial Institute was in 1914. No evidence from the Imperial Institute has been taken since 1914.

"The criticisms made in the Report on the new Executive Council are misleading. No allusion is made to the fact that the Council is now an administrative body, including representatives of the Home and Dominion Governments, of India, of the Colonies and Protectorates and of the commercial community. The Council is advised and assisted in carrying on the work of the Institute by a large number of special Committees,[1] including distinguished experts of all kinds.

"The views and recommendations of the Commissioners in reality refer to the former system of management and not to the new Constitution, which they apparently desire to condemn before it has had adequate time to give full proof of its capabilities.

"The Executive Council of the Imperial Institute has been little more than six months at work. In that time it has already done much to strengthen and extend the operations of the Institute, especially in respect of its work on the raw materials of the Empire, and to bring it into more intimate association both with the Dominions and with the commercial community in this country, so that the far-reaching results of its work may be more generally known and utilised.

"The Act of 1916 embodying a new Constitution was passed as a Government measure of urgency in order that the management, which was formerly unduly restricted and virtually in the hands of a small Committee of three members, might be placed on a wider basis and more scope provided for the activities of the Institute. The Institute is now in a strong position to assist the Dominions, which under the new Constitution are for the first time in its history in close touch with its operations and work. The absence of a proper representation of the Dominions was a conspicuous defect in the former system. This defect largely accounted for the want of knowledge of and of sufficient interest in the Institute on the part of the Dominions which is commented on in the Report of the Royal Commission.

[1] *A list of the members of these Committees was published in the previous number of this* BULLETIN (*No.* 1 *of* 1917).

"Many members of the Executive Council in accepting nomination did so under the impression that His Majesty's Government, in framing the new Constitution, were aware of the existence of a draft Report of the Dominions Royal Commission which was favourable to the Institute, and which proposed an enlargement of its sphere of operations and usefulness to the Dominions. It can hardly be supposed that this impression was erroneous since His Majesty's Government would scarcely have initiated legislation of the character undertaken in 1916 unless this draft had been favourable and not in opposition to the intentions of the new legislation.

"The fact however remains that the Report of the Royal Commission takes no account of the important work accomplished for the Dominions since the war, or of the more intimate co-operation of the Institute with the Dominions which is provided by the new Constitution. This fact in itself appears to us to invalidate entirely the conclusions arrived at.

"The first of the conclusions to which we desire to refer in detail is that which recommends that the responsibility for the exhibits now shown in the Galleries of the Imperial Institute should be entrusted to the Royal Colonial Institute and that a portion of the Endowment Fund should be handed over to that body together with the Building and also the title of Imperial Institute. Whether the Royal Colonial Institute is a more suitable body than the new Executive Council of the Imperial Institute to manage and improve the exhibition of the raw materials of the Empire and to take charge of public funds, is a matter for His Majesty's Government to decide. It may be observed that India contributed very substantially to the foundation of the Imperial Institute and to the erection of the Building, and would need to be consulted as to the proposed transfer of the Building with the Indian Collections and portion of the Endowment Fund to a body which has hitherto had no direct connection or concern with India. On this proposal we desire also to make the following observations:

"1. The new Executive Council is selected precisely on

the same lines as the Imperial Development Board suggested by the Royal Commission to perform similar and also more important functions. On the other hand the Royal Colonial Institute is a body composed for the most part of those interested in Colonial questions, who are willing to become subscribers chiefly on account of the social amenities and instructional advantages, in the form of lectures and papers, which are offered by that body.

"2. Although the establishment of a 'Museum' was one of the original intentions of the Royal Colonial Institute, the 'Museum' was never established by that body, and at a later date authority was given by Royal Charter to the Imperial Institute to form comprehensive collections in illustration of the natural resources of the Empire.

"3. It may be admitted that in some of the Dominions the Royal Colonial Institute is better known than the Imperial Institute, the principal reason being that the operations of the Royal Colonial Institute differ entirely from those of the Imperial Institute, and naturally lend themselves to a wider field of publicity. It may also be admitted that in the past, through want of close co-operation with the Dominions, but chiefly through want of funds, some small part of the exhibits of the Dominions in the Galleries of the Institute may have been open to criticism, although the Report of the Royal Commission greatly magnifies these defects and gives a wholly wrong impression of the nature and completeness of the exhibits of other countries of the Empire. The statement made in the Report that the tendency has been for the Galleries 'to become a repository of the past' is not justified by the facts.

"As soon as the new Executive Council had been formed it took steps to confer with the representatives of the Dominions on this subject, and through the special Committees for the Dominions now at work, the Council has secured effective support in the improvement of the exhibits and their maintenance up to date. The Council also intend to use every endeavour to render the exhibits of raw materials of further practical value and to increase their use for commercial purposes by circulation throughout the

country. The Raw Materials Committee appointed in connection with the Institute by the Association of Chambers of Commerce of the United Kingdom is actively co-operating with the Council in this work.

"4. It will be seen that action was taken by the new Executive Council as soon as it was formed, little more than six months ago, to strengthen the connection of the Institute with the Dominions by arranging for the appointment of a special Committee for each Dominion, with the High Commissioner as chairman. In all these circumstances it is difficult to explain the conclusion of the Commissioners that they 'see no prospects that, under the present system, the exhibits are likely to be maintained at a satisfactory level or that the relations between the administration of the Imperial Institute and the self-governing Dominions can ever be placed on a satisfactory footing.'

"5. The essential fact must be borne in mind that the value for commercial purposes of the Collections at the Imperial Institute chiefly depends on their association with a scientific and technical staff, having expert knowledge of their nature, composition and the possibilities of their utilisation. The proposed separation of this staff with its laboratories and workshops from the Collections of raw materials would be detrimental to the interests of all concerned. If the management of the Exhibition Galleries were handed over as suggested to the Royal Colonial Institute, this body would need to form a similar scientific and technical staff if the Collections are to serve any commercial purpose.

"6. The Commissioners do not appear to realise that their recommendation in respect to the Royal Colonial Institute is, in reality, a proposal to revert to the first constitution of the Imperial Institute when it was managed by an unofficial body. It is well known that under this management the exhibits in the Galleries were fragmentary and incomplete. Considerable space is devoted in the Report to a description of this first constitution, which concludes with the remark, 'It will suffice to say that as originally constituted it was mismanaged, that part of its work was left undone and part done imperfectly, and that

new organisation became imperative.' In face of this experience there would seem to be no case for reverting to management by an unofficial body.

"Passing now to a consideration of the proposals made in reference to what is called the 'Research work' of the Imperial Institute, it may be observed that the disintegration of the Institute, recommended by the Commissioners, ignores the urgent necessity for an Imperial Clearing House in this country for information as to the sources of supply and for preliminary investigation respecting the utilisation of the raw materials of the Empire as a whole. If the recommendations of the Commissioners were carried out, this most valuable aspect of the work of the Imperial Institute would entirely disappear, and a fatal blow would be struck at what is undoubtedly a most essential auxiliary to the promotion of inter-Imperial trade. In our opinion this feature should be most carefully preserved and developed to the fullest extent so that the organisation for the purposes of exhibition, investigation and the collection and supply of information respecting Imperial raw materials, whether from the Dominions, India or the Colonies, shall be preserved within the domain of one and the same body.

"In considering more in detail the recommendations made with reference to the scientific work of the Imperial Institute, it seems desirable to remove one misunderstanding which appears to run through all the findings of the Commission in reference to this branch of the question. The phrase 'scientific research' has a definite and fundamental connotation. Research of this description does not constitute the principal part of the activities of the Institute. On the contrary, the main purpose of the work of the Institute is practical and commercial, and laboratory investigations, supplemented by technical trials, of materials, are definitely directed to this purpose. The Institute does not interfere or overlap with the work of Universities and Colleges and other Institutions for specialised scientific research here or in the Dominions, but it is able to act as a central clearing house for information and the distributor of suggestions to other institutions for more extended and specialised

research regarding raw materials, as the outcome of the results of those preliminary investigations conducted at the Institute which are limited to the commercial requirements of the case.

"The Report of the Commissioners makes no reference to the large and important body of technical and commercial work, as distinguished from purely scientific research, which in recent years the Institute has accomplished for the Empire, distinct from, but complementary to, the operations of the Board of Trade, and to those of the commercial representatives of the Dominions in this country. Neither does the Report allude to the appointment by the new Executive Council of various technical Committees including distinguished scientific and commercial specialists to advise in connection with the work of the Institute; nor does it refer to the appointment by the Association of Chambers of Commerce of a Committee composed of representatives of Chambers of Commerce throughout the country in order to enable the results of the work of the Institute to be fully known to and utilised by the industrial and commercial community of this country. The recent arrangement with the Board of Trade as to the supply of commercial intelligence is also ignored. By this arrangement the sphere of the Institute is recognised to be that of a clearing house for technical and commercial information respecting the raw materials of the Empire, their sources of supply and utilisation and a basis for the close co-operation of the two bodies is provided.

"It cannot be doubted that the Dominions benefit by these new arrangements. Considerably more work has been done by the Imperial Institute for the Dominions since the war began (a fact which seems to be unknown to the Commissioners), and this shows that a genuine demand for assistance from the Dominions now exists. In contending that 'research' is best conducted for the Dominions in the Dominions, and that therefore the connection of the Institute with the Dominions should be severed, the Commissioners lost sight of the fact that the Institute has never attempted to conduct any kind of research which could be as well conducted in the Dominions, and they fail to

recognise that the most important sphere of the operations of the Institute is not 'scientific research,' but mainly such laboratory and technical investigation as is required to find employment for the raw materials of the Dominions. This may mean either the establishment of an industry in the Dominions with the aid of the accumulated knowledge and experience of similar industries at home or the discovery of a suitable market in this country, or elsewhere in the Empire, for a material which it may be necessary to export. It is obvious that this work can be most effectively conducted in this country. The Imperial Institute possesses an organisation and staff qualified by many years' experience which is in constant communication with the various branches of commerce and industry and only needs extension to fulfil completely the purpose in view.

"The new Constitution of the Imperial Institute expressly provides for a better representation of the Dominions and for a close and continuous connection between them and their representatives in this country and the work of the Institute. Although only recently formed it is already clear that the special Committees for the Dominions will be the means of initiating enquiries of great importance to be undertaken by the Institute for the Dominions. Since the war many enquiries conducted by the Institute for the Dominions have been attended with most useful results. Of these it is only necessary to mention the case of boxwood, which through the agency of the Institute, since the war, has been introduced from South Africa to this country as a substitute for the boxwood of Turkey, and an important trade created in this commodity. For South Africa also the possibilities of commercial utilisation of materials for paper-making, of drugs and of minerals, have been demonstrated, whilst at the recent request of Sir Jan Langerman an enquiry is to be undertaken as to the prospects of utilising certain waste materials as sources of potash. Minerals from Australia for which a market was required have been successfully dealt with by the Institute, and orders have in consequence been given by British firms in this country. Numerous minerals have been received from Canada and Newfound-

land, and in addition much general information has been supplied. The utilisation of fibre waste is being dealt with for New Zealand. Reference may also be made to the enquiries conducted in connection with the disposal of Indian raw hides, which before the war went to Germany and Austria. Through the activities of the Institute a large prospective market has now been indicated not only in this country but in Canada and South Africa for this important export of India.

"Many other examples could be quoted from the recent work of the Institute to prove the high importance of the Imperial Institute as an agency for promoting inter-Imperial trade and the necessity of including all the countries of the Empire within its operations.

"The success of the work described in the preceding paragraphs depends on its being carried on by a specially trained and experienced staff in connection with a representative collection of samples of raw materials from all parts of the Empire, which are available at one centre for investigation and for reference and also for distribution to manufacturers. It would be a most retrograde step to break up and distribute this organisation as is proposed by the Commissioners.

"The Commissioners observe in the course of their Report that the Imperial Institute, 'if it is to fill the purpose of its designers, ought to occupy an important place in Imperial organisation.' We are confident that the new Constitution provided for the Institute by the Act of 1916, with its Committees for the Dominions and Technical Committees, including distinguished scientific and commercial specialists, will enable the Institute worthily to fulfil the important purposes for which it was brought into existence if only adequate financial support is afforded to the Council to carry out its programme of work with effectiveness. We would recall the emphasis laid on this point by Lord Milner in his speech during the debate in the House of Lords last year when the Imperial Institute Act was under discussion. We hope that this financial support will now be granted. We submit that the findings of the Dominions Royal Commission in regard to the

Imperial Institute are not justified by the facts, and we trust that they will not be accepted by His Majesty's Government.

"(Signed) ISLINGTON.
EMMOTT.
BURNHAM.
THOMAS MACKENZIE.
R. M. KINDERSLEY.
WYNDHAM R. DUNSTAN.

"APRIL 11, 1917."

In a leading article in the *Times* of March 27, 1917, on the Report of the Dominions Royal Commission, the following allusion was made to the recommendations relating to the Imperial Institute:

"The Commission commit themselves, too, to severe strictures on the Imperial Institute. They recommend that its galleries should be handed over to the Royal Colonial Institute; that the Dominions 'should concentrate their efforts on the development of their own research institutions'; and that 'the research functions of the [Imperial] Institute should be limited to work for India, the Crown Colonies, and the Protectorates.' We hold no brief for the Imperial Institute, but we think these strictures over-severe. The Institute has been hampered by lack of funds and an awkward constitution. As lately as last year an Act was passed giving it a new constitution, subject to the general control of the Colonial Secretary. It should at least be given the chance of showing what it can do under this new scheme."

The following leading article appeared in *The Daily Telegraph* of February 26, 1917:

"The friends of the Imperial Institute, and those who know and value its work, will learn with the utmost astonishment that a serious attempt is about to be made to compass its destruction. Only last year, under the Imperial Institute Management Act, the government of the Institute was entirely remodelled and, subject to the general control of the Colonial Secretary, was placed under a large and

representative council of twenty-five members. But even this radical change of management was by no means so important as the vigorous steps which were immediately taken to extend and co-ordinate the already existing operations of the Institute, and, above all, to increase their practical utility and commercial value on the one hand to the Empire, and, on the other, to the manufacturers of Great Britain. That has been attended with such marked success that the motives which prompt so surprising an attack will be the more carefully scrutinised. It comes from an unexpected quarter. The Dominions Royal Commission will shortly issue a final report, in the course of which the suggestion, we understand, is made that the Imperial Institute should be dissolved, and its work distributed between the Board of Trade and the Royal Colonial Institute, leaving only the work of scientific investigation to be retained, but restricted and transferred to another building. The Board of Trade is represented as being quite capable, through its Commercial Intelligence Department, of doing all that is now done by the Institute in the way of collecting and disseminating commercial information, and the Royal Colonial Institute, it is suggested, would show greater skill in the arrangement of, and greater enterprise in securing specimens for the exhibition galleries than the present directing authorities. There was a time when the public collections of the Imperial Institute were justly open to the sharpest criticism, and when the whole place seemed to be suffering from blight and premature decay. But there is no justification whatever for describing the collections, as they are to-day, as 'a repository of the past.' They are, on the contrary, kept well up to date, and are continually being renewed, and they are as attractively presented as the collections of any public museum in London. Representative committees of the various countries have been formed, specially charged with the care of seeing that the collections are made as complete and as interesting as possible, both to the casual visitor and to those who attend the galleries for educational or commercial purposes. As for the proposed transference to the Board of Trade of the

duty of collecting commercial intelligence, the fact is that the Board of Trade only recently determined that, as the work was being done so well by the Imperial Institute, it should in future form a definite part of its functions. In the same way, the Secretary of State for India not long ago showed his confidence in the new India Committee of the Institute by entrusting to it the duty of inquiring whether more general use might not be made of the raw materials of India by the manufacturers of Great Britain. The new policy of the Institute has been to take a much more active share than ever in the commercial development of those undeveloped Imperial estates which have suffered neglect so long. When it was formed in 1888 there were no very clear ideas as to what purpose it was to serve, and, even if there had been clear ideas, there certainly was no disposition on the part of successive Governments to give its directors the requisite backing and support. But now it perceives its path of Imperial usefulness plain and clear before it.

"Already good progress has been made in a strictly practical direction. The idea that the Imperial Institute only exists for the sake of its collections is entirely mistaken. It exists mainly for the sake of developing the raw materials of the Empire and for bringing the Colonial producer into touch with the home manufacturer. Since the re-organisation a dozen special expert committees have been appointed, each connected with some important branch of trade. For example, there is a committee which deals with fibres of all kinds, with jute and with cotton. Another deals with food grains; another with hides and tanning materials; another with gums and essential oils; another with drugs, tobacco, and spices. Others specialise on timber and paper materials, silk production, rubber, etc. In each case the object is the same. It is to find the best possible use of all Empire-grown products within their respective categories, to encourage the manufacturer at home to use these products, and to let the producer know what are the manufacturer's difficulties in turning them to commercial use, so that if possible they may be overcome. A change has come over British manufacturers in recent

years, which has been enormously accentuated by the war. They used to be disinclined to consider substitutes; they took raw materials irrespective of their place of origin. Now they are more ready to experiment, and if they have any prejudices after the war, it will be wholly in favour of Empire-grown raw materials. Hence the efforts to develop cotton-growing in the Empire, with admirable results achieved already, and the successful attempts made during the war to discover new Imperial sources of supply of raw materials for which we had previously depended on foreign countries. In a recent debate in the House of Lords,[1] it was stated by Lord Islington that it was due to the Imperial Institute that West Africa was supplied with coal of her own, that certain rare earths used in the processes of the gas mantle industry were found in Ceylon, that mica was discovered in Nyasaland, and that an effective substitute for Turkish boxwood was found in South Africa. Certain districts have lately been found in India where the opium yields as good results in the production of morphine as Turkish opium; effective substitutes for Prussian potash have also been found in the Punjab. These are only a few examples of the fields in which the research side of the Imperial Institute has proved its practical utility, and it will be seen with general gratification that its laboratories are devoted not to pure scientific research, but to scientific research in its relation to commerce and manufacture. Yet, strangely enough, it is being attacked on this very side, and the most formidable enemies of the Institute are not those who have signed the report of the Dominions Royal Commission—especially as it is known that their draft report referred to the Institute in terms not of depreciation but of commendation. In the debate in the House of Lords of last December[1] the only speaker hostile to the Imperial Institute was Lord Haldane, and he opposed any further public grant and assailed its research work, not for its inferior quality, but because it had not been brought into relation with the Research Committee of the Privy Council, in the formation of which he himself took a leading part, and because it had nothing

[1] See this BULLETIN (No. 1 of 1917).

to do with the Imperial College of Technology, another of his favourite educational children. The best answer to all such criticism is accomplished result, and of this the Imperial Institute can show much, and will show more, if the State will but provide the necessary funds for the increase of staff, machinery, and laboratories. The Institute is not an isolated institution working aimlessly *in vacuo*. On the contrary, it is closely in touch with the Associated Chambers of Commerce, with a large number of important business firms, especially in the rubber, tanning, dyeing, and fibre industries, and with the authorities of India, the Dominions, and the Crown Colonies. Moreover, what is more important, in view of the adverse conclusions of the Commissioners, we believe the Imperial Institute will be found, when the matter comes to the test, to have the confidence of the Dominions, in whose name, but without whose authority, this unreasonable condemnation may seem to the public to have been uttered."

GENERAL ARTICLE

PRODUCTION AND USES OF RICE

In previous numbers of this Bulletin (1913, **11**, 634; 1914, **12**, 85) an article was published on the cultivation and preparation of rice, in the course of which the varieties of rice, methods of cultivation and preparation, pests and diseases were described, and some account of the production of this grain in the British Empire was given. In the present article it is proposed to deal with the production of rice and its commercial movement, especially in the British Empire, and with the uses of rice.

Since the war it has become apparent that the resources of the Empire in food and raw materials have not hitherto been used to meet the needs of the Empire itself to anything like the extent that is desirable, and rice is a striking example of this state of things. Thus India, which produces about 40 per cent. of the world's exportable surplus of rice, distributed its exports in 1913-14 in the following proportions: to British countries 42·6 per cent., to foreign countries 57·4 per cent. The gross imports of rice into the British Empire were little less than the total exports of rice from India, so that it would be quite possible to find a market within the Empire for nearly all the rice India can spare for export.

Of the exports of Indian rice in the year 1913-14 Holland

took 13·8 per cent., Germany 13·1 per cent., and Austria-Hungary 8·7 per cent., the United Kingdom coming next among European countries with 6·7 per cent. While this country occupied a relatively unimportant position as a direct importer of rice from India it imported considerable quantities of rice from Holland and Germany, which had been first exported from India to those countries, and after being milled and polished there had been re-exported to England. Rice-milling, at one time a flourishing industry in this country, had declined before the war owing to severe competition from the Dutch and German mills, with the result that not only was the British home market partly supplied by foreign-milled rice, but what was at one time the considerable British export trade in fully-milled rice had been reduced in many directions. Since the war both the home and export trade in milled rice have been largely recovered by the British rice-millers, and it is hoped that this industry and trade may be retained after the war.

It is clear from this brief statement of the position as regards rice that there is much leeway to make up in the way of developing inter-Imperial trade in food and raw materials. So far as Indian exports of raw materials are concerned, the possibility of increasing the usage of these raw materials within the Empire is now being fully investigated by the Committee for India of the Imperial Institute at the request of the Secretary of State for India, as already announced in this BULLETIN (1916, **14**, 461). In connection with that enquiry a Special Committee has investigated the trade in rice, and has now almost completed its work. It has become apparent in the course of that enquiry that something can be done to increase the market for rice, and especially for Indian rice, within the Empire. It is hoped that this article will assist in that direction by giving precise information as to the present production of rice and the demand for this grain within the Empire, the general tendencies of the trade, the directions in which markets should be sought, and various uses to which rice is as yet scarcely applied within the Empire.

Terms Employed.—Before being hulled to remove the husk, rice is known as paddy, or rough rice. After the hulling process it is known as "cargo rice." After being milled for the removal of the outer skin it is known as skinned or white rice. A final milling process turns out polished rice—the article of ordinary domestic consumption in the Western world. At each stage various by-products are obtained.

In statistics of rice production and trade it is important to know to what precisely they refer, as there is a big difference both in volume and in weight between a given quantity of paddy and its yield of polished rice, with lesser differences, of course, between the intermediate stages.

Often this information is not available, owing to lack of uniformity in the terms employed to denote the different stages. In the published statistics of most countries, indeed, the only distinction drawn is between "paddy" and "rice." The *Crop Estimates* of the Indian Department of Statistics give the calculated production (weight) of "cleaned rice," which, according to *Agricultural Statistics of India*, is obtained by deducting from 33 to 38 per cent, (the proportion differs slightly in different provinces) from the estimated weight of the paddy crop. According to the *Review of the Trade of India*, one maund of paddy gives 25 sers (⅝ maund) of rice, or 62½ per cent. by weight. In the present article cleaned rice of this description has been adopted as the standard, and the fraction employed in converting paddy statistics (weights) to their rice equivalent has been ⅝, unless official usage in the country in question favours a different proportion. In British Guiana, for example, paddy is reckoned to yield ⅗ (60 per cent.) of its weight in rice, while the ratio adopted by the United States Department of Agriculture is 100 : 162, or just under 62 per cent.

By volume the proportion of rice obtained from paddy is less. For purposes of rough-and-ready reckoning two measures of paddy are generally regarded as equivalent to one measure of rice. This proportion has been adopted here for countries which record their paddy statistics in measures of volume. To assist comparison with other countries, volumes of rice have further been reduced to their weight equivalent at the rate of 2½ bushels to 164 lb. (about 65½ lb. per bushel), this being the rate adopted by the Ceylon Customs (see Ferguson's *Ceylon Handbook*).

World Resources

From the crop returns which are available for some countries, and from the estimates of normal production in others, it may be calculated (see table on page 254) that the world's output of cleaned rice in 1916-17, excepting that of China, amounted to about 60,000,000 tons. Of this the British Empire produced about 36,000,000 tons, almost wholly in India, where the crop (including an allowance of 1,000,000 tons for Native States) was no less than 35,000,000 tons. Of the foreign production of 24,000,000 tons, over 20,000,000 tons was grown in five countries—Japan, Netherlands East Indies (chiefly Java), French Indo-China, Siam, and Korea. The estimates of production in China are largely guess-work and differ widely. The *Yearbook* of the United States Department of Agriculture, 1914, quotes an estimate which claimed a production of over 21,000,000 tons in 1910 for three provinces only—Yunnan, Hunan and Kiangsi; on the other hand, the *China Year Book* for 1916 says that the annual production of rice in

China is officially estimated at 3,750,000 tons. Both the extent of country over which rice is grown in China and the numbers of the Chinese who consume it as a staple article of diet suggest that the production of rice in China is not likely to be much inferior to that of India, and may exceed it. Possibly 40 per cent., or a little less, would be a fair allowance for India's proportion of the world's annual production of rice.

To quote again the United States agricultural *Yearbook*, the quantity of rice which entered into international trade in 1913 may be estimated from the export returns of different countries at about 6,400,000 tons. This includes exports from European countries which import partially milled rice, complete the milling process, and do a re-export trade in the finished product. Even so, more than three-fourths of the export trade in 1913 was done by India (chiefly Burma), Siam and Indo-China. Among producing countries these three alone play any large part in international trade in rice. Of the total exports of 6,400,000 tons, as calculated by the United States Department of Agriculture, those from India amounted to 2,570,000 tons (40 per cent.), while those from French Indo-China (1,260,000 tons; nearly 20 per cent.) and Siam (1,130,000 tons; nearly 18 per cent.) together amounted to almost as much. The chief importing countries were, in order, Japan, Netherlands East Indies, Germany, Netherlands, British Malaya, Ceylon, the United Kingdom, China and France. As will be seen later, the increase of her own crops has altered materially Japan's position as an importing country since 1913.

In the following notes on the countries of production, British countries are considered first, and then foreign countries; in both groups the arrangement is geographical.

BRITISH EMPIRE

India.—The predominant position occupied by India in respect of the world's production of rice and trade in rice has already been seen. In India itself the cultivation of rice is of prime importance among agricultural industries. According to *Agricultural Statistics of India*, out of a gross area of 261,000,000 acres[1] under crops in British India in 1914–15, 78,000,000 acres, or 30 per cent. of the whole, were under rice. This was more than three times the area under any other food grain in British India. In Assam, rice occupies nearly 80 per cent. of the cultivated land; in Burma, 74 per cent.; in Bengal, 70 per cent. In addition to the area under cultivation in British India, it was estimated in 1913–14 that 2,500,000 acres were under rice in Native States, this estimate being only partial, as a number of Native States do not furnish returns.

[1] The area cultivated was 228,000,000 acres, of which 33,000,000 acres were cropped more than once. In the gross totals, areas cropped more than once are counted as separate areas for each crop.

The acreage and production of rice in British India in the last five years, according to the estimates (forecasts) issued by the Department of Statistics, have been as follows:

Year.	Area under rice. Acres.	Production (cleaned rice). Tons.	Yield per acre. Cwts.
1912–13	71,623,000[1]	28,485,000[1]	8·0
1913–14	75,425,000	28,790,000	7·6
1914–15	76,181,000	27,964,000	7·3
1915–16	78,152,000	32,824,000	8·4
1916–17	79,700,000	34,079,000	8·6

[1] *Not including Central Provinces and Berar.*

These estimates cover 99 per cent. of the total rice area of British India, and also the Native States in the Bombay Presidency and Sind. On the other hand, the estimates for Bombay and Sind relate only to the chief rice-growing districts.

The distribution of the acreage and production between the different Provinces in 1916–17 was as follows:

Province.	Area.		Production.	
	Acres.	*Percentage.*	*Tons.*	*Cwts. per acre.*
Bengal	21,120,000	26·5	8,028,000	7·6
Bihar and Orissa	16,442,000	20·6	8,898,000	10·8
Madras	11,377,000	14·3	5,536,000	9·7
Burma	10,520,000	13·2	4,417,000	8·4
United Provinces	7,156,000	9·0	2,675,000	7·5
Central Provinces and Berar	5,086,000	6·4	1,481,000	5·8
Assam	4,265,000	5·4	1,406,000	6·6
Bombay	2,430,000	3·0	1,094,000	9·0
Sind	1,220,000	1·5	490,000	8·0
Coorg	84,000	0·1	54,000	12·9
Total	79,700,000	100·0	34,079,000	8·6

The acreage and production of rice in each Province in 1916–17 per head of the population, on the basis of the 1911 census returns, are shown in the following table. The figures are not, of course, absolutely true, but are instructive for comparative purposes. The calculations relate to the population of British India only, as distinct from Native States of every description.

RICE ACREAGE AND PRODUCTION (1916–17) PER HEAD OF POPULATION (1911)

Province.	*Acres.*	*Cwts.*
Bengal	0·46	3·5
Bihar and Orissa	0·48	5·2
Madras	0·27	2·7
Burma	0·99	8·3
United Provinces	0·15	1·1
Central Provinces and Berar	0·37	2·1
Assam	0·64	4·2
Bombay	0·15	1·4
Sind	0·35	2·6
Coorg	0·48	6·2

It will be seen that though Burma was only fourth among the Provinces of British India in 1916–17 in respect of total area under rice and production of rice, it was easily first in respect of both acreage and production per head of the population. This is its normal relationship to the other Provinces, and as a result its crop is of the first importance in the rice export trade. Besides sending large quantities of rice to other Indian Provinces to supplement local supplies,[1] Burma furnishes 70–75 per cent. of the total exports of rice from India. In the latest year of normal trade, 1913–14, India exported 2,419,863 tons of rice not in the husk, and of this amount 1,834,998 tons were exported from Burma. The exports of rice in the husk (paddy) are comparatively small, ranging in the quinquennium ending 1913–14 from 30,000 to 55,000 tons per annum. The total exports in 1913–14 formed .9 per cent. of the estimated production, and the average proportion of exports to production in the quinquennium ending 1913–14 was also 9 per cent. The distribution of the exports of husked rice in 1913–14 is shown in the following table, which includes all countries to which more than 50,000 tons were exported. Java is included, as being usually among such countries.

EXPORTS OF RICE FROM INDIA IN 1913–14

Destination.	*Tons.*	*Per cent.*	£
Ceylon	335,059	13·8	3,162,450
Straits Settlements	284,589	11·8	1,915,029
United Kingdom	161,409	6·7	1,129,677
Egypt	53,884	2·2	371,097
Mauritius and Dependencies	51,344	2·1	503,988
Other British countries	144,878	6·0	1,189,541
Total British countries	1,031,163	42·6	8,271,782
Holland	333,732	13·8	2,026,221
Germany	315,895	13·1	2,096,054
Austria-Hungary	211,442	8·7	1,370,032
Japan	160,646	6·6	1,076,886
Asiatic Turkey	81,057	3·4	665,869
Java[2]	39,412	1·6	261,158
Other Foreign countries	246,516	10·2	1,831,580
Total Foreign countries	1,388,700	57·4	9,327,800
All countries	2,419,863	100·0	17,599,582

It will be seen that three British countries—Ceylon, Straits Settlements and the United Kingdom—took about one-third of the total exports, and three foreign countries—Holland, Germany and Austria-Hungary—took another

[1] Imports of rice into these other provinces (chiefly Bengal and Bombay) from abroad, though relatively small, are actually considerable in some years (41,462 tons valued at £404,551 in 1915-16, nearly all from the Straits Settlements).

[2] The exports to Java in the years 1909-10 to 1912-13 were 103,000 tons, 258,000 tons, 278,000 tons and 160,000 tons.

third. This statement is approximately true not only for the year 1913–14, but for the last five years before the war.

During the war the exports of rice from India have fallen off considerably; they dropped to 1,538,000 tons in 1914–15 and to 1,340,000 tons in 1915–16, *i.e.* to little more than half the quantity exported in 1913–14. This is due to the loss of enemy markets and the shortage of shipping, and has come about in spite of greatly increased exports to the United Kingdom, amounting to 297,000 tons in 1915–16. There is an export duty of 3 annas per maund (3*d.* per $82\frac{2}{7}$ lb.) on rice from India, and the revenue of the Government of India from this source declined from £858,000 in 1913–14 to £553,000 in 1914–15 and £508,000 in 1915–16. In view of the predominant position it occupies in the rice export trade, Burma has been the Province chiefly affected, but it has been helped over the difficulty by finding increased markets for its surplus produce in other parts of India, partly owing to a shortage in certain Provinces, and partly owing to the fall in the price of rice, which has enabled other Provinces to buy more freely from Burma. The importance of this branch of Burmese trade in normal times as well as during the war is shown by the following table:

EXPORTS OF PADDY AND RICE FROM BURMA

Year.	Foreign trade.[1]	Coasting trade (with other parts of India).		
		Paddy.	Rice.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Average of 5 years 1906–7 to 1910–11	1,457,000	298,000	609,000	907,000
1911–12	1,930,000	104,000	141,000	245,000
1912–13	2,062,000	76,000	190,000	266,000
1913–14	1,855,000	277,000	612,000	889,000
1914–15	1,126,000	316,000	907,000	1,223,000
1915–16	960,000	276,000	956,000	1,232,000
1916–17	1,215,000	159,000	869,000	1,028,000

[1] *Exports under this head consist almost entirely of husked rice, the quantities of paddy included amounting to only from* 10,000 *to* 29,000 *tons per annum in the eleven years covered by the table.*

It has already been stated that Burma's exports of rice to countries outside of India form about three-fourths of the total exports from India. The other fourth, exported from other provinces, includes rice required for consumption by Indian coolies abroad, and varieties specially grown for the European market, such as Patna rice. India's total exports of rice in 1913-14 were fully equal to the gross requirements of the rest of the British Empire; but more than half the Indian exports went to foreign countries, while Indo-China and Siam sent a corresponding quantity to British countries. The following are the figures:

EXPORTS OF RICE FROM INDIA IN 1913–14

To British countries.	To foreign countries.	Total.
1,031,000 tons.	1,389,000 tons.	2,420,000 tons.

EXPORTS OF RICE TO BRITISH COUNTRIES FROM INDIA, SIAM AND INDO-CHINA

	Tons.
India (1913–14)	1,031,000
Siam (1913–14)	810,000
Indo-China (1913)	491,000
Total	2,332,000

These are the returns of primary distribution, not of final destination. The above exports of rice from Siam and Indo-China went almost entirely to the distributing centres of Singapore and Hong Kong. Part of the Indian rice exported to foreign countries (notably Germany and the Netherlands) found its way to the United Kingdom after being cleaned and polished. During the war, this trade has been largely recovered by the British mills. It may not be practicable to limit the rice trade of the Empire wholly to British countries; but efforts might at least be made to maintain the British rice-milling industry at such a level after the war that Indian rice for consumption within the Empire shall reach its destination without the intermediary of foreign countries. Another point to be borne in mind is the importance of increasing the low average yield of rice in India. Up to a certain point, increased production would be absorbed by increased local consumption, but beyond that point even a small percentage increase of the total would mean a big percentage increase in the exportable surplus. There is plenty of scope for effort in this direction. In 1916-17, a good year, the average yield of cleaned rice in India was 958 lb. (8·6 cwts.) per acre. In Italy (1916) the average yield was 18 cwts., in Spain (1916) 29 cwts., while in both Egypt (1915) and Japan (1916) it was between 21 and 22 cwts. per acre.

Active steps are being taken in India to improve both the quality and the yield of the rice crops. In Burma, which is of primary importance from the point of view of the export trade, over 100 tons of improved rice seed were distributed for the first time in 1915–16 from the Hmawbi Experimental Station, and a similar quantity will be available from the Mandalay Farm during the present year. It is also proposed to start a seed and demonstration farm in each district of the Pegu Division. The following notes on rice production in Burma, extracted from a paper contributed to the International Congress of Tropical Agriculture at the Imperial Institute in 1914 by Mr. A. McKerral, Deputy Director of Agriculture in the Southern Circle, Burma, are instructive.

Burma has three climatic zones: (1) a southern tract with 70 to 200 in. of rainfall, (2) a northern area with 60 to 100 in., and (3) a central or dry area with 25 to 35 in. The main crop is from the first area, embracing the deltaic

plains, where the soil varies from a sandy loam to a darkish clay of lateritic origin. Owing to the rapid hardening of the soil after the rains are over, the cultivation can only be by means of irrigation. Manuring is done in the nurseries, but scarcely at all in the transplanted fields. Only cattle manure is used, green manuring being impossible owing to the soil and the sudden approach of the monsoon; weeds, however, are ploughed in when possible. Four main varieties of crops are recognised: (1) Early, maturing in 75 days; (2) medium, maturing in 75 to 100 days; (3) long lived, up to 120 days; (4) glutinous varieties, used for special purposes, and never exported. The short-lived varieties are grown in the higher lands of the deltaic region, the long-lived in the lowest lands. The reaping of the main crop is done in December and January, largely by coolies from Madras and Bengal.

Mr. McKerral put the yield in Lower Burma at 1,500 to 4,000 lb. of paddy (say 8·4 to 22·3 cwts. of cleaned rice) per acre. According to the Indian crop estimates for 1916–17, the average yield of rice throughout Burma was 8·4 cwts. per acre, against an average yield of 8·6 cwts. per acre for India as a whole. Cropping is continuous, and there are no rotations, with the result that the natives complain of declining yields. Hence Mr. McKerral reached the conclusion that Burma had arrived, before the war, at the stage of necessary transition from extensive to intensive methods of rice cultivation. Such a conclusion is strengthened by the further fact that the rice acreage of Burma, in the chief rice districts, has practically reached its natural limit, and increased production can only be achieved in those districts by more intensive cultivation. This is the more necessary in the interests of Burmese agriculture because there are no competing crops in the great rice-producing area of Lower Burma, though in certain parts of Upper Burma paddy is faced with possible competition from sugar cane, and lately there has been a movement to substitute wheat for paddy. Not only improved methods of cultivation, but improved methods of marketing the rice crop demand attention. At present Burmese rice is not in the highest category, the defects being chiefly due to (1) premature harvesting; (2) faulty storage; (3) damage from insects; (4) excess of red grain, whose presence in the mill damages the other grain; (5) excess of awned grain having the same effect; (6) mixture of several varieties in one sample; and (7) the presence of dust and grit.

These and other problems are under investigation at the two Government Experimental Stations at Mandalay and Hmawbi. To avoid glutting the market when the main crop is harvested it has been suggested that the rice should be stored in elevators. These are considered to be of doubtful value under the conditions which obtain in

Burma, but storage sheds have been erected in recent years, with promising results in the way of extending shipments over a longer period. With regard to the preparation of the crop for shipment, up-to-date mills owned by European firms are established at Rangoon, the chief centre of the rice trade, and also at the ports of Bassein, Moulmein, and Akyab. A large number of small mills throughout the country are owned by Chinese and Indians.

Ceylon.—The cultivation of rice is the principal industry of the native agriculturist in Ceylon. The area under crop is subject to considerable fluctuations from year to year. In 1911 it was officially estimated at 644,763 acres, in 1912 at 801,024 acres, in 1913 at 671,711 acres, in 1914 at 685,147 acres, and in 1915 at 785,100 acres. Over a period of twenty years before the war (1894 to 1913) production showed little more variation than might be expected from such fluctuations, and from the differences between good and bad seasons. The range of the official crop estimates in that period was from 10 million bushels of paddy to 16½ million bushels, the latter return (for 1912) being quite exceptional. If the relation of paddy to rice by volume be reckoned as 2 to 1, and the weight of rice in relation to volume as 164 lb. per 2½ bushels, the annual production of rice during the twenty years is found to have ranged from about 145,000 tons to 240,000 tons. The average for the period was about 11,500,000 bushels of paddy, or 168,000 tons of rice. The returns available for 1914 and 1915 are not complete, but the production showed little variation from the average. In 1915 the official crop estimates for all districts but Matara (where there were 42,000 acres under paddy cultivation) amounted to 11,145,553 bushels of paddy, equivalent to 163,000 tons of rice. This gives an average yield of only 4·4 cwts. of rice per acre, and a proportionate allowance for Matara would bring the total production in 1915 up to 172,000 tons.

In 1913, when the area under paddy was returned as 671,711 acres, and Matara was credited with the unusually high yield of 13 cwts. of rice per acre, the total crop was estimated at 12,822,761 bushels of paddy, or 187,750 tons of rice. This gives an average yield of 626 lb. (5·6 cwts.) per acre, which is much lower than in India. Taking the paddy acreage of 1915 (785,100 acres), and the census population of 1911 (4,109,470), the area under crop per head of the population works out at no more than 0·19 acre, which is also much less than in most of the rice-growing provinces of India. Hence it is not surprising that production in Ceylon is not nearly equal to the needs of the population. Imports of rice in recent years have been about double the quantity produced locally. These imports are mostly from India, and amounted in 1913 to

376,678 tons of rice and 26,309 tons of paddy—equivalent to a total rice import of 393,121 tons. In 1914 it was 387,218 tons, and in 1915 it was 376,159 tons.

One of the chief impediments to progress appears to be the apathy of the native farmers. Experimental work has been carried out, and various suggestions have been made as to methods by which the Government could assist and encourage the farmers, but up to the present little has been achieved. An important question is that of irrigation, a large part of the rice area of the island being still dependent upon the rainfall; but though it would no doubt be possible to extend irrigation to these parts, the more immediate prospects of improving the cultivation of rice would appear to lie in the proper utilisation of the areas that are already easily irrigable from the tanks. The Mannar District, where rice is grown under irrigation from the Giant's Tank and the works connected with it, is a good example of such an area; for an account of the cultivation of rice in this district reference may be made to *The Tropical Agriculturist* (1915, **45**, 157). In many cases a lack of organised co-operation between native cultivators is a bar to the proper carrying out of irrigation schemes; as a paddy field may sometimes belong to as many as fifty owners, it is evident that in the absence of co-operation little progress can be made.

Malaya.—In British Malaya, as in Ceylon, though rice cultivation is an important native industry, the production does not equal the consumption, nor are there any immediate prospects that it will do so. On the contrary, the annual reports on both the Straits Settlements and the Federated Malay States for the year 1915 refer to the growing neglect of rice cultivation, and the former report says: "From rice a Malay might expect, if the season did not fail, to make with the united labour of his wife and family a bare livelihood. A small rubber plantation yields him enough to make him a comparatively rich man; and instead of the dried fish and the cloth garment that were all that he could afford as a rice-grower, he eats imported rice and dresses himself and his family in silks. Such of the rice fields as are not cultivated are lying fallow, and cultivation can be resumed when required."

The uncertainty of the rice crop under present conditions of cultivation is an important contributing cause of its decline in native favour. In the *Agricultural Bulletin, Federated Malay States* (1912–13, **1**, 161), Mr. N. W. Barritt defined the main requirements of successful cultivation as (1) protection against the ravages of rats and wild pigs; (2) an adequate water supply under control; (3) the maintenance of soil fertility; and (4) protection against insect and fungoid pests. The Agricultural Department of the Federated Malay States has been giving serious atten-

tion to these and other problems. In the Krian district of Perak, where extensive irrigation works have been established, some 50,000 to 60,000 acres have been brought under cultivation. The results have not been an unqualified success in all parts of the district, but it has been demonstrated that rice can be grown profitably where the crops have hitherto failed, if there is careful regulation of the water supply. Experience in the Krian area tends to show, also, that the natives are eager to engage in rice cultivation if there is reasonable prospect of success.

In the Straits Settlements, mainly in Malacca and Province Wellesley, there are about 91,000 acres under paddy cultivation, and in the Federated Malay States about 125,000 acres. Among the Unfederated States, Kelantan is credited with 93,000 acres, and the little State of Perlis with 20,000 acres. The rich alluvial plain of Kedah, adjoining that of Perlis, is largely devoted to rice cultivation, while in Trengganu, on the opposite side of the peninsula, the main plain contains a limited area of rice land which is also fully settled and cultivated. The yield of paddy in the Federated Malay States in 1913, according to a report by the Director of Agriculture, was 3,143,542 bushels. This was equivalent to about 46,000 tons of rice, or about 819 lb. (7·3 cwts.) per acre. If the average yield in other parts of the peninsula was about the same in 1913, the production in the Straits Settlements in that year might be roughly estimated at about 35,000 tons, in Kelantan at about 35,000 tons, and in Perlis at about 7,000 tons. No data are available for estimates of the production in other parts of British Malaya.

As regards trade, the imports of paddy into the Straits Settlements have gradually increased from 59,238 tons in 1911 to 109,559 tons in 1915, while exports (including re-exports) have declined from 7,435 tons to 2,891 tons, the balance of imports over exports thus increasing in the five years from 52,000 tons to 107,000 tons. The net imports of rice have not increased at the same rate, for while gross imports have risen steadily from 595,156 tons in 1911 to 759,177 tons in 1915, exports in the same period have risen from 472,702 tons to 664,093 tons, the net imports for the five years being 122,000 tons, 194,000 tons, 162,000 tons, 182,000 tons, and 95,000 tons. Moreover, in estimating the position in British Malaya as a whole, it must be borne in mind that from 30 to 40 per cent. of the exports from the Straits Settlements go to other parts of the Malay Peninsula. If the returns for this inter-state trade be excluded from both the import and export accounts, the net imports of paddy into British Malaya through the Straits Settlements are found to have increased from 20,000 tons in 1911 to 70,000 in 1915, while the net imports of rice for the five years have been 296,000 tons, 396,000 tons, 368,000 tons,

385,000 tons, and 302,000 tons. These figures show the extent to which British Malaya is dependent on outside countries (chiefly India, Siam and Indo-China) for its supplies of one of the staple foods of its native population.

In the Federated Malay States alone, while there is a small net export trade in paddy, amounting to a few thousand tons annually, there is a net import trade in rice which amounted to 132,000 tons in 1905, whereas in each of the years 1913–15 it was from 174,000 tons to 190,000 tons. The increase in the ten years denotes the growing dependence of the Federated Malay States on outside sources of supply to meet its needs in rice.

Among the Unfederated States, Kelantan is practically self-supporting in respect of rice. In Trengganu, according to an estimate by the British Agent, there is a total net import of rice, after allowing for the export of paddy, of about 6,000 tons. From Kedah there were exported in 1914–15 about 8,000 tons of rice and 39,000 tons of paddy, and from Perlis (from the accumulated stocks of two or three years) between 8,000 and 10,000 tons of paddy and rice. On the other hand, Johore imported about 31,000 tons of rice in 1915. On the whole, therefore, the supplies and requirements of the Unfederated Malay States may be said approximately to balance.

British North Borneo.—Rice is grown by the natives as one of their staple food crops. In the season 1914–15 an attempt was made for the first time by the Director of Agriculture to estimate the area under cultivation and the crop. The area under "wet" paddy was returned as 19,498 acres, of which 13,474 acres (two-thirds) were in the West Coast Residency and practically all the remainder in the Interior Residency, the East Coast Residency being credited with only 12 acres. The wet paddy crop in 1915 was 420,318 bushels, equivalent to about 6,154 tons of rice, or 707 lb. (6·3 cwts.) per acre. The area under "dry" paddy was returned as 31,597 acres, of which 18,980 acres (three-fifths) were in the Interior Residency, and the remainder chiefly in the West Coast, Kudat, and Sandakan Residencies, the return for the East Coast being again very small—86 acres. The dry paddy crop reaped in 1915 was 249,703 bushels, equivalent to about 3,656 tons of rice, or only 259 lb. (2·3 cwts.) per acre. The smallness of the average production of dry paddy was largely due to drought, the crop being a complete failure in some districts. The combined returns for wet and dry crops show the total area under cultivation as 51,095 acres, and the total crop as equal to 9,810 tons of rice, or 430 lb. (3·8 cwts.) per acre. Of the total area planted with paddy, 24,992 acres, or one-half, were in the Interior Residency, and 17,655 acres, or one-third, in the West Coast Residency.

For the following season, 1915–16, the area returned as planted with wet paddy was 22,299 acres, and with dry paddy 27,169 acres, a total of 49,468 acres, or slightly less than the total for 1914–15.

Apart from drought and such pests as rats, the small average production is partly explainable by the primitive methods of cultivation. Even in good years production is far from being equal to consumption, taking the country as a whole. In the published trade returns the imports of rice are not shown separately, but the imports of "Rice, Flour and Grain," which largely consist of rice, increased from about 8,000 tons in 1903 to about 15,000 tons in 1913. In the latter year the Sandakan Residency alone imported 4,625 tons of rice. The exports of paddy and rice—really in the nature of re-exports—are rarely more than about 200 tons per annum; in the period 1903-13 the maximum figure was 585 tons in 1907.

In his report for 1913 the Governor stated: "The native population grows about sufficient for its own consumption in an average year, but does not seem inclined to extend cultivation to any appreciable extent, in spite of the excellent market available for any surplus rice. It is to the Chinese settlers that the country must look for supplies in the future. Any amount of suitable land is to be had for the asking, and it is to be hoped that with the active assistance of Government in the important matters of drainage and irrigation enough rice may be produced eventually to feed the whole of the Asiatic population, and thus retain in the country some $750,000 (£87,500) per annum at present expended on importation of foreign rice." In the Agricultural Report for 1913 it was noted that foreign seed paddy introduced in 1912 appeared to be much appreciated both for its quality and its rapid growth.

Sarawak.—Rice is largely grown by the natives, and to a less extent by some of the Chinese settlers, but the country is not self-supporting in rice. There is little trade in paddy; imports and exports amount in some years to a few hundred tons, with the balance now on one side and now on the other. But the importation of rice is on a comparatively large scale, and is a Government monopoly. In the five years 1912–16 the quantities imported were 13,100 tons, 11,600 tons, 10,500 tons, 12,400 tons, 16,650 tons.

Hong Kong.—The total area under crop in the colony in 1916 was 47,629 acres, of which 33,942 acres were under paddy. Of the paddy area 2,100 acres produced one crop, 20,342 acres produced two crops, and 11,500 acres produced two crops of paddy and one catch crop. There are no returns of production. Precise returns of the trade of Hong Kong are also lacking. According to returns (not compulsory and not vouched for officially) which are

furnished by shipmasters and published in the annual reports on the colony, the annual imports of rice in the years 1909–14 inclusive ranged from 550,000 tons to 750,000 tons. A United States Commerce Report published April 26, 1917 (No. 97, p. 338), stated that the total turnover of rice on the Hong Kong market in 1916 was placed by commercial estimates at 820,000 tons, or perhaps 20,000 tons above the turnover in a good normal year. The imports are mostly supplied by French Indo-China and Siam. The imports from Indo-China consist principally of whole cleaned rice, and from Siam of broken white rice. China gets the bulk of her imports of rice and paddy, which amount in some years to over half a million tons, through Hong Kong.

Australia.—The production of rice in Australia is at present a negligible quantity, though there are considerable areas suitable for growing rice, especially in the tropical and sub-tropical parts of the continent—North-Western Australia, the Northern Territory, and Queensland. A quarter of a century ago rice was grown on more than 1,000 acres in Queensland, but it was never a popular crop, and its cultivation has become practically extinct in that State; one acre was planted with it in 1915. Commenting on the dwindling production, the Report on Agricultural and Pastoral Statistics of Queensland for the year 1914 stated that "this grain struggles for a home in Queensland but does not succeed." Efforts to revive the industry have not, however, been abandoned. Though the rice crop has been quite insignificant for many years, details of it have regularly been given in the Queensland crop returns, and the *Queensland Agricultural Journal* has repeatedly sought to stimulate interest in the subject. In an article recalling the past cultivation of rice in the State and indicating the potential value of the industry, the *Journal* (1916, 5, 224) stated: "It seems strange that, whilst we have thousands of acres of land admirably suited for rice-growing, we have allowed the industry to drop, and import rice to the value of £96,000 a year, all of which could be as easily grown as wheat or maize and to a greater profit, employing, as in other rural industries, only white labour." The districts in which rice used chiefly to be grown are the Cairns district, in North Queensland, and the Logan district, in South Queensland, near Brisbane. The portion of the Logan district known as Pimpama Island, lying between the Logan, Albert and Pimpama Rivers, is particularly well adapted to rice cultivation, the best results having been obtained from the variety known as White Java. The yield in this area has frequently amounted to 40 bushels of paddy (about 12 cwts. of cleaned rice) per acre. In the ten years 1906–15 the

average yield from all rice plots in Queensland varied from 11 to 38½ bushels, the highest area under cultivation in any one year being 24 acres.

In the Northern Territory considerable attention has been given to the experimental cultivation of rice, both on the Government Farms and in the Botanic Gardens at Darwin. On Batchelor Farm 50 acres were sown in December 1914 with Java rice of different varieties. Grown primarily for fodder, the crop averaged about 2 tons of hay to the acre. Part which was left for seed produced about 20 bushels of grain per acre. The yield both of hay and grain would have been much greater if the dry season had not set in much before its time. In his report for the year 1914–15 the Administrator says: "It has been demonstrated that rice may be grown as an ordinary crop suitable for chaff as fodder, and probably, with a better year's rainfall, for milling."

While tropical Australia would seem to be the most promising field for rice-growing in the Commonwealth, the experimental cultivation of rice has been practised for some years in both Victoria and New South Wales. Such success as has attended these experiments is due mainly to the enterprise of Mr. I. Takasuka, a Japanese settler at Tyntynder, on the Murray River, who has developed by selection a variety bearing his own name. It is claimed that the seed germinates at a temperature of 56 degrees, and that the plant does not suffer from frosts. In 1914–15, with an inadequate water supply, Mr. Takasuka obtained an average of 10 cwts. of rice per acre from an area of 10 acres. In the *Journal, Department of Agriculture Victoria* (1916, **14**, 493) were reported the results of a trial cultivation of Takasuka seed by an Australian farmer near Koyuga (not far from the junction of the Murray and Goulburn Rivers). The yield was at the rate of 756 lb. (6¾ cwts.) of hulled rice per acre, and led to the suggestion that crops should be grown for grain in seasons of plentiful water supply and for fodder in dry years. These crops would utilise low-lying land which at present is too wet for wheat. There are said to be thousands of acres of such land along the Murray River and elsewhere in Victoria.

At the Yanco Experiment Farm, in the Murrumbidgee irrigation area of New South Wales, a plot of Takasuka rice, grown in 1915–16, was spoiled by hot, windy weather. At the Grafton Experimental Farm, in the north-east corner of the same State, where trials in earlier years with other varieties met with little or no success, a small plot under Takasuka rice gave a return of fodder at the rate of over 2 tons per acre and of grain at the rate of nearly 7 cwts. per acre. The *Agricultural Gazette, New South Wales* (1916, **27**, 799) stated that the grain was large and of excellent quality, while the foliage was soft and

succulent, apparently of high feeding value, and much relished by stock.

Farmers with suitable land have been showing their interest in these various trials. Last year the crops of Takasuka rice, grown by private enterprise at Tyntynder and Koyuga, were sold for seed purposes at from 1s. to 2s. per lb. As an ordinary commercial proposition, rice-growing in both Victoria and New South Wales, as in other parts of Australia, has still to prove its value. At Koyuga it was calculated that if the crop (6¾ cwt. per acre) had been sold for food purposes, and had realised 2*d*. per lb. (£18 13*s*. 4*d*. per ton), there would have been a profit, after allowing for all expenses, including rent of land, of 16*s*. per acre. With larger experience it was hoped to secure a larger crop. The Australian farmer has an advantage in the Australian tariff, which imposes import duties of 3*s*. 4*d*. per cental (100 lb.), equivalent to £3 14*s*. 8*d*. per ton, on uncleaned rice, and 6*s*. per cental (£6 14*s*. 5*d*. per ton) on other forms of rice, unless the rice is imported for the manufacture of starch, when it is given free entry. In addition the Commonwealth Bounties Act of 1907 made provision for a bounty of £1 per ton on uncleaned rice produced in Australia during a period of five years; but the *Official Year Book* of the Commonwealth states (1916 edition) that no such bounty has been paid.

Before the war, in the year 1913, Australia's imports of rice, according to the Commonwealth trade returns, had grown to 24,882 tons of "uncleaned" rice, of which 14,856 tons paid duty; 7,595 tons of rice "N.E.I." (not elsewhere included), of which 4,944 tons paid duty; and 13 tons of rice meal and flour. The uncleaned rice comes almost entirely from India, and according to the Indian trade returns it consists of "rice not in the husk," so that presumably it denotes rice which has been husked (cargo rice) but not fully milled. As regards the Australian imports of cleaned rice, China shares with India the great bulk of the trade. There is a re-export trade from Australia, which includes only a trifling quantity of uncleaned rice (5 tons in 1913), but reaches considerable proportions in respect of cleaned rice (6,072 tons in 1913), and rice meal and flour manufactured in Australia (2,126 tons in 1913). These exports go to New Zealand and the Pacific islands. In the first year of the war, 1914-15, imports were lower and exports higher. There were imported into Australia 19,406 tons of uncleaned rice, of which 18,873 tons paid duty; 7,224 tons of rice N.E.I., of which 4,041 tons paid duty; and 8½ tons of rice meal and flour; while exports amounted to 50 tons of uncleaned rice, 9,786 tons of cleaned rice, and 2,325 tons of rice meal and flour. The imports of uncleaned rice averaged in value, before payment of customs duty (£3 14*s*. 8*d*. per ton), nearly £9 per ton in 1913 and between

£7 and £8 per ton in 1914-15; imports of rice N.E.I. averaged in value, before payment of duty (£6 14s. 5d. per ton), over £13 per ton in 1913, and nearly £12 per ton in 1914-15.

New Guinea.—The climate of Papua (British New Guinea) is stated to be very congenial to rice; but little if any of this cereal is grown by either natives or Europeans. In the five years 1910 to 1914-15 the exports of rice from Australia to Papua averaged 689 tons, with a minimum of 516 tons in 1913 and a maximum of 826 tons in 1912, when the export value was £10,650.

Experiments of an elaborate character have been made in rice cultivation at one of the mission stations in "German" New Guinea, and in 1912 it was reported that the prospects were very promising.

Fiji.—Indian settlers in Fiji have developed the cultivation of rice until it has become the third most extensive crop in the colony. Expanding and contracting from year to year, with a marked upward tendency over a series of years, the returns of land under rice increased from 10,183 acres in 1910 to 14,195 acres in 1915, when they formed 10 per cent. of the total returns of cultivated land (excluding native cultivation). The two crops in Fiji covering larger areas were sugar cane, 62,308 acres (44 per cent.), and coconuts, 45,102 acres (32 per cent.). The production of rice in 1915 was returned as 18,157 tons, or about 25½ cwts. per acre. The returns do not specify whether this is rough rice, husked rice, or cleaned rice; and it is doubtful to what extent the estimate can be relied on. Exports are practically nil. The production is unequal to the consumption, and in spite of an import duty of £2 per ton, the average annual imports of rice in the five years 1911-15 were 1,981 tons, the extremes being 1,317 tons in 1914 and 2,573 tons in 1915.

The Agricultural Department has engaged in the experimental cultivation of rice, but without much result, so far as can be gathered from its annual reports. In the report for the year 1914 it was mentioned that, as part of an effort to encourage the natives (Fijians) to extend the range of their crops, arrangements had been made to supply them with seed rice, and brief directions for planting rice had been translated into the Fijian language.

Egypt.—In normal years rice has a regular though minor place among Egyptian crops. According to the *Annuaire Statistique de l'Égypte*, in the ten years 1903–4 to 1912–13 inclusive the area under rice cultivation varied from 234,000 to 298,000 acres. From 90 to 95 per cent. of this acreage was in Lower Egypt, and the whole formed between 3 and 4 per cent. of the total cultivated area in Egypt. In 1913–14, owing to the abnormally low level of the Nile, the area

under rice dropped to 37,000 acres, but in 1914–15 it increased again to 331,000 acres, forming just over 4 per cent. of the total cultivated area. According to the crop report of the International Institute of Agriculture, Rome, the production of "rough rice" (paddy) in 1915 from an area of 331,000 acres was 585,000 tons, this being about 45 per cent. above the average for the quinquennium 1909–13. The equivalent production of cleaned rice in 1915 may be taken to have been about 366,000 tons, or 21·5 cwts. per acre. This is between two and three times the average yield in India.

Egypt does a moderate export trade in rice of her own production (almost entirely with Turkey before the war), but imports, as a rule, much larger quantities of cheaper rice, mostly from India, for home consumption. Last year the balance of trade was reversed. The following are the returns for the five years 1912-16:

Year.	Imports. *Tons.*	Re-exports. *Tons.*	Exports. *Tons.*
1912	33,793	230	24,740
1913	53,442	86	23,169
1914	49,514	29	13,077
1915	24,464	78	10,422
1916	7,752	50	22,473

Anglo-Egyptian Sudan.—In his report for the year 1915 the Director of the Commercial Intelligence Branch of the Sudan Government Central Economic Board mentioned the extended cultivation of rice as one of the most promising means of reducing the dependence of the Anglo-Egyptian Sudan on imports from abroad. At present rice is being grown in the Southern Provinces, notably the Bahr-el-Ghazal, only on a small scale, but the results are considered to justify efforts to extend its cultivation as soon as means are available. Samples received at the Imperial Institute from time to time have, at their best, been described by brokers as much superior to Rangoon rice; the quality has not, however, been uniformly good.

As yet the local demand is rather limited. Imports of rice, though considerable, are not a very big item in the total imports, and do not point to rice as a very important article of native diet. The population is estimated at nearly 3,500,000, and in the last few years rice imports (chiefly from India and Egypt) have been: in 1910, 1,815 tons; in 1911, 2,199 tons; in 1912, 3,136 tons; in 1913, 2,505 tons; in 1914, 3,073 tons; in 1915, 1,200 tons. It will be seen that the imports in 1915 (1,200 tons) were less than half the average imports during the previous five years (2,546 tons). In 1916 they increased again slightly to 1,620 tons. A small re-export trade, chiefly with Eritrea and Arabia, has developed in the last few years—25 tons in 1914, 157 tons in 1915, 111 tons in 1916.

Uganda Protectorate.—Only the merest beginnings have been made with rice cultivation in the Uganda Protectorate. The Blue Book for 1915–16 gave the ascertainable area under rice as 254 acres, practically all in the Buganda and Eastern Provinces. Several excellent Upland varieties can be grown, and a much larger area might be cultivated, especially in the rainy districts bordering the Victoria Nyanza; but hitherto efforts to bring the crop into favour with the natives have met with little success. The natives eat little rice themselves, and have trouble in husking the paddy, which in the rough state is practically unsaleable. The Department of Agriculture is showing much perseverance in trying to overcome these difficulties. The Director's report for 1915–16 stated that "further efforts have been made to extend rice cultivation, with some success, particularly in Bukedi and parts of the Northern Province. The local demand for rice is good, and there is every reason to hope that this will be satisfied in the coming years by local production." Imports during the five years 1911–12 to 1915–16 ranged between 352 tons (1915–16) and 562 tons (1913–14), the chief source of supply before the war being German East Africa.

East Africa Protectorate.—Rice is grown to some extent by the natives in the coast zone and in the country bordering the Victoria Nyanza. The Director of Agriculture, in his report for 1913–14, stated that the area under rice was increasing, and mentioned in particular that large swamps in the Mumias and Kisumu districts (near Lake Victoria) had been drained and brought under cultivation. There is even a trifling export of locally grown paddy, decreasing from 27 tons in 1911–12 to less than 2 tons in 1914–15, the intervening period embracing a series of dry years. In 1916 only 5 cwts. were exported.

Production is nothing like equal to the requirements of the population (which includes a considerable Indian community), and imports of rice, chiefly from India, ranged from 6,295 tons in 1910–11 up to 8,178 tons in 1914–15. In 1915–16 imports dropped to 5,352 tons, valued at £58,421; but rice was still first among the imports of grain in respect of both quantity (56 per cent.) and value (52 per cent.). There is a 10 per cent. import duty on rice.

The experimental cultivation of Upland varieties has been tried on the Government farms at Mazeras, near the coast, and at Kibos, near the Lake. At both places the experiments have been hampered by droughts; but in a good season at Kibos a yield of 1,100 lb. (9·8 cwts.) per acre was obtained from a 2-acre plot.

Zanzibar and Pemba.—Rice is cultivated in both islands by the natives for their own use, but not in large enough quantities to supply local needs. In Zanzibar it is grown

in the low, swampy flats; in Pemba it is mostly grown in the swampy valleys, but very fair crops are also grown on the hillsides. The conditions in Pemba especially are very favourable to rice cultivation, and in the days of slave labour, when rice is said to have been grown by the Arabs in nearly every valley, a considerable export trade existed. With the decline of the plantation industry the water courses in many of the larger valleys have become choked with weeds, and the ricefields have degenerated into swampy wastes. The natives prefer more easily cultivated crops, such as mahogo (cassava). A good deal of rice is still grown, however, in Pemba, and as prepared locally it is stated to be far superior to any that can be bought in the open market, though owing to the laborious way in which it is harvested it could not compete commercially with cheap Indian rice. (See Capt. J. E. E. Craster's *Pemba.*)

There are considerable imports of rice into Zanzibar, coming almost entirely from India. A very large proportion of these imports are retained for local consumption. Normally most of the re-exports go to the mainland; German East Africa took the bulk of them in 1913. In the official returns the trade in rice is recorded in "packages." From the value assigned to them the net imports may be put at between 10,000 and 20,000 tons.

Mauritius.—A local variety of "wet" rice was formerly grown in Mauritius by irrigation, but its cultivation was given up partly because land was wanted for sugar, and partly because the Indian population preferred Indian rice. Indian varieties have been introduced, and are grown by peasant proprietors at Grand Post, but the area under cultivation is not large enough to be separately recorded in the published returns of agricultural industry in the island. Trials with different kinds of seed are being made by the Agricultural Department. Rice is the chief article of food of the majority of the population (376,000 in 1914, of whom 261,000 were Indians), and the annual imports amount to from 50,000 to 60,000 tons, mostly obtained from India.

Nyasaland.—Introduced among the natives by the Arabs and the Portuguese, the cultivation of rice in Nyasaland was encouraged under British rule partly in order that local supplies might be available for the native troops, for whom about 500 tons per annum were required, and partly in order that the natives might be provided with a means of paying their hut tax in kind. A promise was given that, as far as possible, a market would be found for any surplus production. At present the development of the industry is just about adequate to the local needs. Rice does not figure in the import returns; in some years a few tons are exported. The crop varies a good deal according to the season. In the six years 1911–16, the smallest crop was

717 tons in 1914, and the largest 1,317 tons (preliminary estimate) in 1916. There are large tracts in the lake region suitable for rice, and cultivation could probably be extended if freight and other charges permitted of its export at a price which would both offer inducement to the natives to grow it, and enable it to compete with other supplies in open market.

Rhodesia.—Rice is grown by the natives in both Southern and Northern Rhodesia. In Southern Rhodesia its cultivation was so far successful that in 1905 the *Rhodesia Agricultural Journal* (1904–5, 2, 84) raised the question of adopting rice as a staple crop. But the results of experimental work have not been encouraging, and instead of rice becoming a staple crop, the Director of Agriculture, in his report for the year 1909, noted a widespread tendency among the natives to abandon their old crops—millets, Kaffir corn, and rice—in favour of mealies, beans, and ground nuts. Rice is not much favoured by the natives in the western districts of Southern Rhodesia, and where it is still grown in other parts of the country it generally supplies purely local and individual needs. Rice is eaten by many of the natives in the mines, especially by the Nyasaland natives, and for their requirements as well as for those of the white population it has to be imported, chiefly from India. For some years before the war the imports ranged from about 1,500 tons to nearly 2,000 tons, valued at from £15,000 to £25,000; in 1915 and in 1916 the quantity dropped to between 700 and 800 tons, and the value to £10,000.

In Northern Rhodesia the natives cultivate both red and white varieties of rice, the latter having been introduced by the Arabs. The authors of *The Great Plateau of Rhodesia*, Messrs. Gouldsbury and Sheane, both of the Rhodesian service, express the hope that "by gradually fostering the cultivation of rice and of cassava, the natives [of North Eastern Rhodesia] will in time become alive to the easiness with which these foods are grown, and slowly substitute them for their more uncertain crops of millet." In the last few years (1913–16) the annual imports of rice into Northern Rhodesia have ranged from about 30 to 80 tons.

Union of South Africa.—The conditions of rainfall and water supply are not generally favourable to rice cultivation in the South African Union, and there is not much grown, though trial crops in Natal between Tongaat River and Stanger are said to have given good results. There is an ample market within the Union, the net imports of rice for several years past having been between 30,000 and 40,000 tons, with a value of between £300,000 and £400,000. Imports are subject to a duty of 1s. per 100 lb., or about 22s. 5d. per ton.

Gambia.—Rice is grown by the natives in the low-lying, swampy country near the River Gambia. The conditions are favourable to its cultivation, and an irrigation expert who visited the colony some years ago reported that the natives understood this branch of agricultural industry as well as the natives of the East. The crops are so liable to destruction by floods, however, that the quantity grown is limited, and falls far short of the colony's requirements. In 1915, in spite of transport difficulties, the imports of rice amounted to 2,163 tons valued at £27,115. Of this quantity all but 13 tons (which came from Sierra Leone) consisted of Asiatic rice, mostly imported from Europe. Only 19 tons were re-exported, and one ton of locally grown rice was sent out of the country. These figures are typical of the trifling character of all branches of the trade except the imports of Asiatic rice. The average quantity of such imports in the five years 1910–14 was 6,273 tons, and the average value about £67,000, the greater part being supplied before the war by Germany. There is an import duty of 10*s.* per ton. Much larger quantities might be grown within the colony under a proper system of irrigation and protection from floods, but hitherto the cost has been considered by Government to be prohibitive.

Sierra Leone.—This dependency is the premier rice-growing country in British West Africa. There are no crop statistics, but to judge from the import and export returns the production of rice is seldom much short of local requirements. Trifling quantities of African rice are imported from other parts of the West Coast, and considerable quantities from Europe. In 1910 the latter amounted to nearly 7,000 tons, and in 1911 to over 3,000 tons; but in no other year from 1900 to 1915 did they total 1,000 tons, and generally they were less than half that amount. Against these imports have to be set considerable exports of rice grown in Sierra Leone, which find a market in other West African countries. Comparison between the imports and exports is complicated by the fact that while the trade in "European" rice is measured by weight, the trade in African rice is measured by volume, and is divided between rice in the husk and clean rice. Reckoning that two bushels of paddy yield one bushel of clean rice, and that a bushel of rice weighs about 65½ lb., the total exports of home-grown rice from Sierra Leone in the five years 1911–15 work out at 340 tons, 474 tons, 323 tons, 329 tons, 435 tons. The imports of "European" rice in 1915, after allowing for re-exports (14 tons), were 462 tons, or only 27 tons more than the exports of home-grown rice; and the exports were actually the more valuable. No doubt the special conditions created by the war, notably in respect of high prices, were partly responsible for this result in 1915; but

the Governor of Sierra Leone notes that the exports increased in that year, compared with 1914, "in spite of restrictions which it was found necessary to impose on the exportation of rice." There is no import duty on rice.

A former District Commissioner, Mr. T. J. Alldridge, stated some years ago that "Sierra Leone is absolutely a rice country, and can produce any quantity of it." Rice, fish, and cassava are the staple foods of large numbers of the native population, and the production of rice has received much encouragement from Government. Extended cultivation has been reported in recent years from various districts, notably in the neighbourhood of railway construction. Experiments have been carried out by the Agricultural Department with a view to the introduction both of new varieties and of improved methods of cultivation. The value of deep hoeing and green manuring in increasing the yield of local varieties has been shown, and satisfactory trials have been made with Indian and British Guiana rices. The Indian rices are not viewed with favour by the natives, because they are smaller in grain than the Sierra Leone varieties. The brownish colour of the native rice is against its sale on the European market, but the local varieties are well liked along the West Coast, where Sierra Leone rice at present finds its market. There seems to be no doubt that white rices can be grown in Sierra Leone. Apart from the experiments of the Agricultural Department, Mr. Alldridge, so far back as 1905, stated that for some time past a fine variety of white American rice, introduced by American missionaries, had been grown in Sierra Leone with very good results.

Gold Coast.—Rice in the Gold Coast is classed among those minor products whose cultivation "at present is scarcely sufficient to meet local demands, and there is little likelihood of an export industry being started, although there are large areas of available land which might be profitably put under cultivation" (*Report of the Agricultural Department for* 1913). A certain amount of experimental work has been carried out at Agricultural Stations in the Northern Territory, especially at Tamale, where rice has been successfully grown in a three years' rotation, following two crops of cotton. So far, however, from the production of rice in the Gold Coast as a whole becoming more nearly equal to the consumption, imports tend to increase. During the 12-year period for which statistics are available, 1904–1915, the imports of rice advanced from 4,464 tons to 7,696 tons, the minimum for the period being 3,595 tons (value £42,013) in 1907, and the maximum 7,982 tons (value £111,233) in 1913. There are no exports of locally grown rice, and only trifling re-exports. On nearly all rice there is an import duty of £1 per ton, though some

of the imports of rice from neighbouring countries are charged at the rate of 4 per cent. *ad valorem*.

Nigeria.—Rice is grown to a small extent in the Southern Provinces of Nigeria and to a much larger extent in the Northern Provinces, where it occupies a greater area than is under wheat. The locally-grown varieties, which are large in the grain and of a slightly reddish tint when cleaned, are highly esteemed in the Northern Provinces, and command a higher price than the imported white rice. There is little trade movement in rice, either outward or inward, so far as the Northern Provinces are concerned, so that the supplies grown there would seem to be about equal to the consumption; but in the Southern Provinces there are large imports, chiefly from the United Kingdom. In 1915, when there was a scarcity of shipping due to the war, these imports amounted to 5,441 tons, valued at £80,617. In the previous year they were 10,641 tons (£109,520), and in the three pre-war years (1911–13) they averaged 10,896 tons in weight and £119,014 in value.

There is scope for greatly extended cultivation of rice in Nigeria. If such development should take place, it might be necessary to clean the grain more thoroughly than is usual in native practice, to enable it to compete in Southern Nigeria with the imported rice, which is now securely established in the market there. Average yield and price are perhaps still more important factors. Improved transport facilities will help to reduce the cost of marketing the native product, while as to yield the Northern Nigeria Blue Book for 1913 stated: "Imported maize and rice have yielded returns considerably in excess of native varieties, which they are likely gradually to replace."

British Guiana.—Among the agricultural industries of British Guiana the cultivation of rice ranks next in importance to sugar planting. Rice was first introduced from Carolina by the Dutch some two hundred years ago, and it used to be a favourite crop among the runaway slaves; but efforts to develop its cultivation as a settled industry met with little success till towards the close of last century. Since then such rapid progress has been made that in 1915 the area under rice was returned as 50,737 acres—the highest on record up to that year. The rice acreage formed 29 per cent. of the total area under cultivation, the area under sugar-cane being 75,744 acres (43 per cent.), and under miscellaneous crops 49,888 acres (28 per cent.). If allowance be made for holdings from which two crops were gathered, the area reaped was 55,574 acres.

The crop in 1915 was estimated by the Department of Agriculture as 65,700 tons of paddy or 39,420 tons of cleaned rice (the Department reckons the production of rice as 60

per cent. of the paddy by weight). With 50,737 acres under rice, this is equivalent to an average yield of 15·5 cwts. of cleaned rice per acre, which is nearly double the average yield in India, and higher than the average for the United States, though much below that of some other countries, such as Egypt and Japan. In 1914 a smaller area (47,037 acres) under rice cultivation in British Guiana was estimated to have produced a slightly larger crop (39,760 tons of cleaned rice), or an average yield of 16·9 cwts. of rice per acre. Such an average must be regarded as a very favourable feature of the rice industry in British Guiana. The Agricultural Department has shown much enterprise in conducting experiments to discover the most suitable varieties of seed and the best methods of cultivation. Over two hundred kinds have been imported from other countries for trial, and the long-grained varieties find most favour. Among other assistance given to cultivators, the Department distributed in 1915 alone 22 tons of selected seed paddy, or sufficient to plant nearly 1,000 acres.

The rapid expansion of the area under cultivation has been largely due to the industry and skill of East Indian coolies who have settled in the country after completing their terms of contract labour on the sugar estates. Of the 50,737 acres under rice in 1915, 13,600 acres, or rather more than one-fourth, were situated within the empoldered areas of sugar plantations. Very much larger areas of the flat, heavy coastal lands are suitable for rice cultivation; and if the industry continues to expand as it has been doing, British Guiana may become an appreciable factor in the rice trade. Already the position occupied by rice in the colony's own trade has been reversed. Imports, which amounted to 11,300 tons in 1899, dwindled to 2 tons in 1915, while exports, which began with 5 tons in 1902–3, increased to 9,058 tons in 1915, nearly all going to the British West Indies. In addition there are small exports of paddy (172 tons in 1915) and rice meal (266 tons in 1915). The rice produced, both for local consumption and for export, is "brown" rice, which is obtained by soaking and steaming the paddy before it is milled. White polished rice is not favoured, and the numerous rice mills which have sprung up in the colony are specially adapted to the manufacture of brown rice. A cattle food known as "colco" has been made from rice tailings and molasses.

Trinidad.—Rice-growing in Trinidad is chiefly done by settlers of the Indian coolie class. The report of the Agricultural Department for 1915 gives the area under rice cultivation in 1914–15 as 12,328 acres (out of a total cultivated area of about 450,000 acres), against 10,410 acres in 1909–10, an increase of 2,000 acres in five years. On the

other hand a report drawn up in January 1917 by a Special Committee of the Board of Agriculture estimated the area under paddy cultivation at about 5,000 acres, and the paddy crop at roughly 40,000 bags of 160 lb. each, yielding approximately 60 per cent. of cleaned rice by weight. On this basis the production of cleaned rice would be rather more than 1,700 tons, and the average yield about 7 cwts. per acre. The report—published in the *Bulletin of the Department of Agriculture, Trinidad and Tobago* (1917, **16**, 15)—stated that swamp rice was principally grown. Upland rice is also cultivated widely, but on a very limited scale. Hitherto the trials made with imported Indian varieties have not given good results; the yield has been poor and the grain not so good as that of local varieties. But some varieties imported from British Guiana have given good results, both in yield and in the quality of the milled product. There are three rice mills—at Port of Spain, St. Augustine, and Chaguanas. These are capable of dealing with more than double the present crop, which is not nearly equal to the consumption. Imports (principally from British Guiana, India and the United Kingdom) amounted to 11,884 tons in 1911, 10,536 tons in 1912, 8,409 tons in 1913, and 11,522 tons in 1914, the value of these imports ranging from £116,284 to £154,472. An import duty of 2*s.* 2*d.* per 100 lb. (about 48*s.* 6*d.* per ton) is levied. A few hundred tons are re-exported, and in 1913 there were exported (to Germany) 9 tons of rice grown in Trinidad. There is a sufficiency of suitable land in the island to grow rice for all local requirements, especially in the swamp lands of Oropuche and Caroni, adjoining the west coast. Most of the lands at present returned as under rice cultivation are in the neighbourhood of these swamps or lagoons. The rice is generally sown in May or June, soon after the beginning of the rainy season, and is harvested about five months later. To encourage increased cultivation the Committee, whose report has been adopted by the Board of Agriculture, recommended prize competitions, the importation of seed rice from British Guiana for sale at the same price as local seed rice, the continuation of experimental work, the opening up to cultivation of suitable Crown lands, and the investigation of proposals for reclaiming certain areas of swamp land by an irrigation scheme. If such a scheme is found to be feasible, it is suggested that the Government might guarantee interest on the capital cost.

St. Lucia.—Rice is grown in small patches by the East Indian labourers employed on the large sugar estates. This statement appears in a pamphlet on the resources of St. Lucia by the Agricultural Superintendent. Imports of rice (practically all for home consumption) in the five

years 1910–14 averaged 262 tons. There is an import duty of 2*s.* per 100 lb. (about 44*s.* 10*d.* per ton).

Jamaica.—Rice is grown in small patches in the Western parishes of the island by numbers of coolies on the sugar estates. They grow it for their own food requirements in swamp lands considered worthless by the proprietors. From the coolies the industry has spread to the creole population, and, though cultivation is still on a small scale, the interest taken in it is much greater than the official returns indicate. In the five years 1909–10 to 1913–14 the area returned as being under rice ranged from 80 to 100 acres; in 1914–15 it was 13 acres, and in 1915–16 it was 12 acres—out of a total of 278,262 acres of tilled lands. Rice, however, from the circumstances of its cultivation, is one of those minor products for which it is difficult to gather adequate statistics; as the Collector-General points out in his report for 1915–16, "perhaps the most that can be said in regard to these minor items is that the agricultural product specified can be and is the object of cultivation." Writing in the *Journal of the Jamaica Agricultural Society* (1917, **21**, 16), Mr. R. C. Somerville, Agricultural Instructor for Southern Westmoreland and Hanover, estimates roughly that there are 500 acres under rice in Westmoreland parish alone. Not only a superior quality of brown or "coolie" rice, but fine white varieties are grown. Rice-milling plants have been erected on two estates. Good results are said to have been obtained by feeding mules on a mixture of rice bran and corn in equal weights. While it remains a coolie and creole industry, rice cultivation must be in small patches, because the cultivators have not the capital to drain the swamp lands on a large scale. But it is claimed that if these lands, forming the Great Morass of Westmoreland, with an area of from 10,000 to 20,000 acres, could be properly reclaimed, they could grow sufficient rice (among other crops) to meet all the needs of the colony and leave a surplus for export. At present there is a large import trade in rice, varying in quantity during the six years 1910–15 from 5,086 tons (1914) to 7,687 tons (1912), with an average of 6,367 tons, the annual value of the imports during the same period ranging between £59,000 and £106,000. An import duty is levied of 3*s.* per 100 lb. (over 67*s.* per ton).

British Honduras.—This colony has not the labour supply required for growing rice on a large scale, though the natural conditions are believed to be very favourable. A little upland rice is grown (the only return given in the Blue Book for 1914 is 50 acres in Toledo District). Crops are said to be of good quality, but very liable to damage from birds. No attempt has been made to grow rice under irrigation. There is a considerable import trade,

valued in the five years 1910–14 at from £9,000 to £11,500 per annum, the average being about £10,000. The quantity of rice imported is not given in the trade returns.

FOREIGN COUNTRIES

Italy.—The largest rice-producing country in Europe is Italy. It easily retains that position, though the acreage of its rice fields has declined by over one-third in the last fifty years, owing to the competition of Asiatic supplies, trouble with disease, and the tendency to grow rice as a rotation instead of a permanent crop. In the quinquennium 1870–74 the area under rice cultivation is said to have been 573,000 acres; in 1916 it was 353,000 acres. The total area of irrigated land on which rice is grown is estimated at over 2,000,000 acres. The yield per acre has increased at a greater rate than the annual area under crop has declined, averaging 9 cwts. of cleaned rice (14·5 cwt. of paddy) per acre in the years 1880–84, and 16·7 cwts. of cleaned rice in the years 1909–14. As a result, the total production has increased. In 1894 an area of 408,000 acres, with an average yield of 9·5 cwts. of cleaned rice per acre, produced a crop of 194,000 tons; in 1916 an area of 353,000 acres, averaging 18·1 cwts. per acre, produced a crop of 320,000 tons.

The chief rice-growing centre is the Vercellèse in Novare Province; thereafter come Lombardy, Venetia, etc. In some irrigated areas cultivation is extending, rice being recognised to be both a weed-cleaning and a profitable crop. The transplanting method of cultivation, introduced by the Experimental Rice-growing Station at Rieti, has proved useful in reclaiming marshes.

Italy not only meets her own needs in rice, but does a considerable export trade. Imports amounted to some 10,000 tons of husked and cleaned rice in 1910, but this was exceptional; in no other year of the quinquennium 1910–14 were they more than a few hundred tons, and in 1912 they were only 38 tons. On the other hand the exports of rice of one kind and another (mostly cleaned rice) are normally between 50,000 and 100,000 tons per annum. In the quinquennium 1910–14 the exports of paddy averaged 9,000 tons (minimum 7,700 tons in 1910; maximum 11,500 tons in 1914); of husked rice (*riso semi-greggio*), 11,650 tons (minimum 2,500 tons in 1910, maximum 18,000 tons in 1912); and of milled rice (*riso lavorato*), 51,270 tons (minimum 36,675 tons in 1910; maximum 62,855 tons in 1914). Of the exports of cleaned rice in 1914 nearly 25 per cent. went to Argentina, over 20 per cent. to Austria-Hungary, 12 per cent. to Germany, 10 per cent. to Switzerland, and 9 per cent. to France.

Spain.—Among European rice-producing countries, Spain ranks next to Italy. Rice cultivation was introduced

into Spain by the Moors, who probably introduced also the transplanting system. The industry is carried on by means of irrigation, and is confined to the east coast provinces, nearly three-fourths of the total area under cultivation being in Valencia. The official delegate for India to the International Rice Congress held at Valencia city in May, 1914, in an article published in the *Agricultural Journal of India* (1914, **9**, 326), expressed the opinion that the cultivation of rice has probably been brought to a higher pitch of perfection in Valencia province than in any other part of the world. Owing to the increased thoroughness of the cultivation, the Andalusian breed of horses has been found to be too light for the heavy work required in the rice fields, and in consequence nearly two-thirds of the horses in the province are now of French (Breton) or mixed origin. The rice lands are mostly permanent, and their cultivation is more nearly according to Indian methods than is the case in Italy, where, as also in Greece, rotational methods mainly obtain. The average yield per annum in Spain is between three and four times as high as in India, a result due to heavier manuring, better cultivation, and the use of improved varieties. It is also more than 50 per cent. higher than in Italy, chiefly owing to the prevalence of transplanting in Spain. In the five years 1911–15 the area under rice cultivation in Spain averaged about 96,000 acres, and production averaged about 125,000 tons of cleaned rice, or 26 cwt. per acre. In 1916 the area under cultivation was about 101,000 acres and the production 148,500 tons of cleaned rice, or 29 cwt. per acre. Thus in 1916 the rice acreage in Spain was less than 30 per cent. of the acreage in Italy; but the rice production in Spain was more than 45 per cent. of the production in Italy.

The chief characteristics of the Spanish methods of cultivation are (1) the universally accepted importance of a thorough cold weather cultivation of the fields, made possible by the use of specially adapted implements; (2) the necessity of employing considerable quantities of suitable nitrogenous and phosphatic manures; and (3) the value of introducing exotic varieties (notably Japanese) with a view to checking deterioration of races cultivated too long in the same locality.

There is an Experimental Rice Station at Sueca, near Valencia.

During the ten years 1905–14 Spain imported between 1,000 tons and 2,000 tons of paddy annually, and usually a much smaller quantity of cleaned rice, though in 1912 (following the failure of the Spanish rice crop in 1911) the imports of cleaned rice rose to 5,670 tons. The exports of rice from Spain in the same decade ranged between 2,000 tons (1911) and 20,000 tons (1913). In 1915 the exports jumped up to 50,000 tons, of which Argentina took 22,000

tons (44 per cent.), Uruguay 8,500 tons (17 per cent.), and Italy 7,500 tons (15 per cent.).

Bulgaria.—The largest area under rice cultivation in Bulgaria in recent years was in 1909–10, when 9,650 acres produced 4,350 tons of clean rice, an average of 9 cwts. per acre. In 1912–13, the latest year for which returns are available, the area under cultivation was 7,220 acres and the production 2,300 tons, or nearly 6½ cwts. per acre.

Greece.—Before the war the returns of land under rice cultivation in Thessaly were increasing rapidly. According to British consular reports, 400 acres planted in 1908 produced 35 tons of rice (whether paddy or cleaned rice is not stated) in 1909—an average of only 1¾ cwts. per acre. The area planted in 1910 was 817 acres and the production (1911) 177 tons—an average of between 4 and 5 cwts. per acre. In 1913 the area placed under cultivation jumped up 3,320 acres and the 1914 crop was 664 tons—4 cwts. per acre.

It has been estimated that in the new provinces of Greece (gained in the Balkan wars before 1914) there are from 2,000 to 3,000 acres normally under rice, and there is also cultivation on a small scale in the districts of Elis, Bœotia and Marathon.

In the decade 1905–14 Greece imported between 5,000 and 6,000 tons of rice annually.

Turkey in Europe.—In the *Annuaire International de Statistique Agricole* covering the decade 1905–14, the only year for which returns are given of rice cultivation in European Turkey is 1910–11, when the area was recorded as 7,327 acres and the production as 1,003 tons of rough rice—say 627 tons of cleaned rice, an average of only 1¾ cwts. per acre. Much of the territory to which these returns related was lost by Turkey in the Balkan Wars of 1912–13.

European Russia.—In 1912–13 it was estimated that 2,929 acres under rice cultivation in the northern districts of Caucasia yielded 693 tons of cleaned rice (nearly 5 cwts. per acre). In 1913–14 the corresponding area was only 1,313 acres and the yield 255 tons of cleaned rice (nearly 4 cwts. per acre).

In the decade 1905–14 the annual imports of rice into the Russian Empire as a whole (European and Asiatic), Finland excepted, were about 100,000 tons, consisting mostly of cleaned rice, while the annual exports were only from 2,000 to 5,000 tons.

Portugal.—In Portugal a certain amount of Government encouragement has recently been given to rice growing, but the facilities offered are not considered sufficient to

induce cultivation on a large scale. At present rice is grown only in a few patches on the coast.

France.—Efforts have been made to popularise rice cultivation in the Rhone delta, and before the war a few hundred acres were under cultivation there.

China.—Mention has already been made, in the brief survey of the world's production of rice, of the difficulty of computing China's contribution to the total. Whether it is actually greater or less than that of India, there is no doubt that it is very large indeed. The country over which rice is grown extends from Manchuria in the north to Yunnan in the south, and the itineraries of travellers in the great rice-producing provinces of Central China abound in references to paddy fields as one of the most prominent features of the countryside. On the other hand, the importance even of rice among the field crops of China must not be exaggerated. It is grown in Manchuria, not under irrigation as in the Yangtse basin, but on dry land like other cereals. Mr. (afterwards Sir) Alexander Hosie noted in 1904 in his book *Manchuria* that rice cost twice as much to buy as tall millet, the staple food of the people, and that it was not extensively grown in that part of China. In his later work, *On the Trail of the Opium Poppy* (1914), he states: "As in Manchuria and North China, rice is a luxury to the peasantry of the north-west." Mr. E. H. Wilson, in *A Naturalist in Western China*, does full justice to rice as the most important foodstuff of the Chinese people, but points out that as it requires an aquatic habitat its area of cultivation is restricted, and "probably a third of the people never taste this grain save on festival occasions."

In an attempt to indicate roughly the northern limit of the area in which rice is grown in China as the staple food-crop, the 32nd parallel has been chosen. This cuts the coast at the mouth of the Yangtse, passes through Nanking, and continues westward to the north of the great middle reaches of the Yangtse. Except in the coastal province of Kiangsu, the amount of rice grown to the north of this latitude is comparatively small. Even to the south of it rice is not universally the staple food of the people. Writing of the north-east corner of Yunnan, Sir Alexander Hosie mentions that the people of the Chao-tung Plain are mostly maize eaters, and those who require rice have to obtain their supplies from a district six or seven days' journey to the south-west.

Similar reservations, however, might be made with regard to the cultivation and consumption of rice in India; and when all due limitations have been imposed on China's claims as a rice-growing country, it remains generally true that "rice is to the Chinese what wheat is to us, only more so" (Wilson). The typical methods of culti-

vation are by irrigation and transplanting; but, as already noted, rice is grown without irrigation in Manchuria, and in Yunnan also upland varieties are grown, though the crops are described as being very inferior to those obtained from aquatic rice. Over most of the rice lands of China one crop per annum, occupying the ground from May till early September, is the rule, but some districts in the south yield two crops in the year. Three main groups of varieties are distinguishable—ordinary, red and glutinous. Only the first two are grown for food purposes. Glutinous rice is sometimes eaten for a change, but its ordinary uses are industrial. It yields a weak spirit, as well as a kind of sugar, and is also used in the manufacture of cakes and sweetmeats. Rice straw is largely used for making bed mattresses and sandals, and to a less extent for making ropes.

Great as is the production of rice in China, it is inadequate to the needs of the vast population. There is a large internal trade, both overland and coasting, but the export of rice abroad is prohibited, and can only take place in small quantities under special arrangements. According to the Maritime Customs returns, exports of rice and paddy in the years 1912–15 ranged from 1,300 to 5,000 tons. On the other hand imports in 1910–15 ranged from 161,000 tons (1912) to 549,000 tons (1910). The imports in 1912 were unusually small, the next lowest figure during the period named being 316,000 tons (1911). Most of these imports are received *viâ* Hong Kong, and no precise figures as to the countries of origin are available; but most of the imports of rice into Hong Kong are derived from French Indo-China (chiefly whole cleaned rice) and Siam (chiefly broken white rice). Hong Kong's total imports of rice, as noted in the section dealing with that colony, have varied in recent years, according to unofficial returns, from about 550,000 to 750,000 tons.

It is possible that the paddy fields of China have been or may be extended by the utilisation for that purpose of lands formerly under poppy cultivation for opium. Sir Alexander Hosie found evidences of such change during his travels in the Yangtse basin in 1911.

Japan. — Among rice-producing countries, as distinct from rice-exporting countries, Japan ranks next to India and China. Known in very early times as "Mizuhono Kuni," "Land of Luxurious Rice Crops," it justifies the description to-day to a greater extent than ever before. In the last forty years, in particular, the increase of production has been very marked. This is partly due to extension of the area under rice cultivation, but more to growth of the average yield. In 1878 the cultivated area was 6,100,000 acres; now it is about 7,500,000 acres, an increase of between 20 and 25 per cent. In 1878 the crop was returned as

25,282,540 koku, or 3,546,000 tons of cleaned rice[1]; in 1916 it was 58,301,680 koku, or 8,177,000 tons, an increase of over 130 per cent. In 1878 the yield per acre averaged between 11 and 12 cwts.; in 1916 the average was between 21 and 22 cwts. per acre. While the increase has been spread over the whole period, it is noteworthy that 1916 was a year of exceptionally heavy crop, as also were the years 1915 (7,843,000 tons) and 1914 (7,995,000 tons). For some years before 1914 the crop averaged about 7,000,000 tons of cleaned rice per annum. The average for the ten years 1907–16—the decade ending with the three years of big crops (about 8,000,000 tons)—was 7,342,000 tons. Improvements in the methods of crop determination may partly account for the sudden increase in the returns for the last three years; but the increase is largely due to recent improvements in the selection of seed and methods of cultivation, as well as to the prevention of damage from natural causes. Even if the last three years be left out of account, it will be seen that the production (7,048,000 tons from 7,422,777 acres in 1913) had nearly doubled since 1878, and that the average yield in 1913 was 19 cwts. per acre, or between two and three times the average yield in British India. With about one-tenth of India's rice acreage, Japan has about one-fourth of India's crop. Such comparisons may be misleading, unless the highly intensive character of Japanese farming is taken into account. According to *Outlines of Agriculture in Japan*, published by the Agricultural Bureau at Tokio in 1910, 70 per cent. of the farmers cultivate less than 1 cho (2·45 acres), and only 3 per cent. cultivate more than 3 cho (7·35 acres).

Rice is easily first among the crops of Japan. It is grown on about half the cultivated area, and provides over half the value of all farm products, including livestock and poultry. About 40 per cent. of the paddy fields carry two crops in the year, the second being usually barley, wheat,

[1] One koku = 4·96 bushels. The *Financial and Economic Annual of Japan* records the production simply as "rice." The United States Department of Agriculture, which estimates the weight of cleaned rice produced in the principal rice-growing countries, used to base its estimate for Japan on the assumption that the Japanese returns related to paddy. In the Department's *Yearbook* for 1916, however, the estimate has been revised to accord with the view that the official figures relate to cleaned rice. The equivalents adopted for the conversion of the returns from volume to weight are not given in the *Yearbook*, but they are evidently, from the results obtained, in close agreement with the equivalents adopted by the International Institute of Agriculture at Rome, namely, 1 koku of rice = 1·425 quintals—*i.e.* 4·96 bushels = 314·16 lb. This works out at almost exactly 63⅓ lb. to the bushel, and agrees fairly well with the reckoning of Messrs. Lockie, Pemberton & Co., quoted in the *Indian Trade Journal*, that 7½ koku = 1 ton—*i.e.* nearly 62⅔ lb. to the bushel. In the interests of international uniformity, the former basis of calculation (1 koku = 314·16 lb., or 7·13 koku = 1 ton) has been adopted in the present article. This does not apply to the section on trade, since in the Japanese trade returns the imports and exports of rice and paddy are already calculated in terms of weight.

rape, or some crop for manuring the soil. In 1914, about 88 per cent. of the paddy fields were devoted to the cultivation of ordinary rice by irrigation, while upland varieties were grown on 4 per cent. of the total rice area, and glutinous rice on the remaining 8 per cent. While upland cultivation accounts for such a small percentage of the whole, it is to be noted that whereas the area under glutinous varieties showed little change in the decade 1905–14, and, if anything, tended to decline, the area under upland rice increased 65 per cent. in the decade. Relatively the areas and production of both upland and glutinous rice are small, but actually they reach a considerable total. In 1914 the area under upland rice was 303,000 acres and the production 158,000 tons. This is equivalent to an average yield of between 10 and 11 cwts. per acre, which is only about half the yield from the irrigated fields. The area growing glutinous rice in 1914 was 619,000 acres and the production 624,000 tons, or over 20 cwts. per acre. Glutinous rice is chiefly used for making pastry and cakes, and as a special foodstuff on fête days. Saké is brewed from non-glutinous varieties. The chief centres of the rice-milling industry are Tokio and Kobé, but milling for local purposes is done in almost every town and village.

Great as the growth of production has been, it failed, prior to the new advance made by the crops of 1914–16, to keep pace with consumption. Prices rose rapidly, and as rice is the staple food of the Japanese, many difficult economic problems were created. The question of the rise in prices was complicated by many factors, including the speculative buying and selling of rice, but these factors were mostly rooted in supply and demand, the supreme importance of which has been clearly demonstrated in the last three years of suddenly increased crops. Before this development, a study of fluctuations in prices and wages in Japan published by the International Institute of Agriculture in Rome led to the conclusion that "in only thirteen years [1900–13] the price of the most important commodity on the Japanese market, of the first necessity for the population, has increased by more than 90 per cent., or on an average by 7 per cent. a year." The acme of this long climax was reached in 1912, when prices for rice were the highest ever recorded in Japan. A sharp decline set in before the crop of 1914 was harvested, and after its magnitude was realised the effect of the fall in prices on the farming industry and on business generally was such that in February 1915 the Minister of Finance was authorised by Imperial ordinance to purchase rice in order to keep up prices to a certain level.

This change in the internal position has naturally reacted on the foreign trade in rice. In recent years, prior to 1914, the crops fell so far short of home requirements

that Japan had come to rank among the great importing countries. A little was exported, chiefly for the use of the Japanese residents in Hawaii, etc., who insist on having rice from Japan, but the balance of the foreign trade was largely on the side of imports. In the twelve years 1901–12 the imports of "rice and paddy" averaged 396,000 tons, the minimum quantity being 136,000 tons (1910) and the maximum 886,000 tons (1904). In 1913 the imports stood at 541,000 tons and in 1914 they still amounted to 299,000 tons. These figures do not reveal the full extent of the imports; they relate only to trade with countries outside the Japanese Empire, in this case principally British India, French Indo-China, and Siam, the first two of these three countries having supplied between 80 and 90 per cent. of the total imports, and Siam most of the remainder. But, in addition, Japan used to get considerable quantities of rice from Korea and Formosa. According to the reports on the trade of Japan in the annual series of Diplomatic and Consular Reports, in the year 1912, when the imports from foreign countries amounted to 333,000 tons, the imports from Formosa were 91,000 tons, and from Korea 36,000, bringing the total imports of rice and paddy up to 460,000 tons. In 1913, when the imports from foreign countries were 541,000 tons, Formosa supplied 158,000 tons and Korea 81,000 tons, making the total 780,000 tons. In 1914, Japan imported 83,000 tons from Formosa and 146,000 tons from Korea, and with 299,000 tons coming from other countries the total reached 528,000 tons. This was the last year of big imports. In 1915 the quantity of rice and paddy coming from foreign countries dropped abruptly to 68,000 tons, and in 1916 there was a further decline to 46,000 tons, the loss of trade being principally borne by India and Indo-China, the imports from Siam being fairly well maintained. Returns of the imports from Korea and Formosa during the last two years are not available, but as regards foreign countries the decline in the imports, coupled as it was with an increase of exports, was sufficient to convert a large import balance into a small export balance. Against the average imports of 396,000 tons from foreign countries in 1901–12, the average exports of rice and paddy were only 58,000 tons, the maximum for the twelve years being 113,000 tons (1902) and the minimum 29,000 tons (1912). In 1913 the exports were still only 29,000 tons, and in 1914 they were 37,000 tons; but in 1915 they jumped up to 93,000 tons and in 1916 to 97,000 tons, the increased trade being mostly with the United Kingdom, the United States, Hawaii, Canada, and Asiatic Russia. Formerly all but a small fraction of these exports consisted of uncleaned rice. In 1915 the proportion of cleaned rice rose to 25 per cent., and in 1916 it was 44 per cent.

In the first five months of the present year (1917) the

exports of rice and paddy (60,000 tons) showed a further increase compared with those for the corresponding period of 1916 (44,000 tons); but imports have also begun to increase again (30,000 tons in the first five months of 1917 against 12,000 tons in the same period of 1916), so that even on the trade with foreign countries, excluding Korea and Formosa, the balance of exports remains small, and may easily become an import balance again if the population continues to increase, and there is no further marked advance in the size of the annual rice crop. In this last connection it must be remembered that Japan is already a very highly cultivated country, having regard to its physical characteristics; but patient industry, combined with agricultural science, has accomplished so much in the way of extending cultivation and increasing the annual yield that it would be unwise to attempt to limit the further advances which may be achieved in these respects.

Korea.—Rather more than a third of the land under cultivation in Korea is devoted to rice. The recorded area of the paddy fields has rapidly expanded in recent years. In the five years before the war the acreage increased by one-third—from 1,914,000 acres in 1909 to 2,560,000 acres in 1913. During the same period the production increased from 1,046,000 tons of rice to 1,414,000 tons (see footnote to section on Japan for rate of conversion from koku to tons). This gives an average yield of between 11 and 12 cwt. per acre. The Japanese administration is devoting much attention to the extension and improvement of cultivation, and if the yield should be brought up to the average in Japan, Korea might take an important place among exporting countries. Already it provides a surplus for export. In the five years (1909–13) the exports averaged 93,000 tons, the minimum being 74,000 tons in 1912 and the maximum 116,000 tons in 1913. Against these exports must be set a smaller quantity of imports (37,000 tons in 1913). About two-thirds of the imports were from Siam, while the great bulk of the exports went to Japan, the balance being taken by China and Asiatic Russia.

As in Japan, the last three years have been years of largely increased crops in Korea. Calculated from British trade reports, giving returns in bushels, the production was about 1,705,000 tons in 1914; 1,595,000 tons in 1915; 1,758,000 tons in 1916. Acreage figures are not available to show how far the increase is due to extended cultivation and how far to improved yield. In 1914 the imports of Japan alone from Korea amounted to 146,000 tons.

Formosa.—Rice is grown throughout the island, and usually two crops are raised in the year. In a Japanese official publication issued in 1914 the area of the paddy

fields was estimated at about 820,000 acres, this being nearly half the total cultivated area. In 1910 the area was estimated at 760,000 acres. As these figures denote, the rice acreage has been extending. Output has also been increased by the progress of irrigation and other improvements in the method of cultivation, though the liability of the island to be swept by typhoons still occasions considerable fluctuations in the crop. The average of the official returns of annual production in the decade 1904–13 is 619,000 tons, the extremes being 557,000 tons in 1906 and 719,000 tons in 1913. In 1914, when several storms damaged the crops, the production was estimated at 647,000 tons. On the basis of the above estimates of the area under cultivation, these crop returns denote a high average yield (from 15 cwts. to 17 cwts. per acre). According to the *Yearbook* of the United States Department of Agriculture, however, the area cropped was about 50 per cent. more, namely, 1,222,000 acres in 1913 and 1,235,000 acres in 1914. As two crops a year are often reaped, the difference may possibly be due to the areas under each crop being counted separately in the larger estimates.

With production on this scale, Formosa has a considerable surplus of rice for export. Until a year or two ago, at any rate, practically all the exports went to Japan. They mostly consisted of unhusked rice. The exports to Japan were recorded in the British consular reports on Formosa as 92,000 tons in 1911, 91,000 tons in 1912, and 157,000 tons in 1913; the report on Japan for 1914 gave the imports from Formosa in that year as 83,000 tons. Rice was imported into Formosa in 1913 to the amount of about 30,000 tons (mostly cleaned rice), of which about one-fourth or one-fifth was from Japan.

French Indo-China.—In Indo-China, as in other countries of the Far East, rice is the staple food of the natives, and the cultivation of rice dominates all other branches of agricultural industry. This is more or less true of all the States comprising France's Indo-Chinese Empire, but both relatively and actually Cochin China is easily first in respect of the extent of its ricefields. Commercially its crop governs the rice export trade of the whole country, and in this connection it may be described as the Burma of Indo-China.

It is only in modern times that the cultivation of rice in Cochin China has attained its present importance. The State has an area of about 20,000 sq. m. (12,800,000 acres) and a population of about 3,000,000. In 1879 there were less than 1,000,000 acres under paddy; by 1887 the area had increased to 2,000,000 acres, and by 1902 to 3,000,000 acres. In 1907, a year of record exports, the figures for which have not yet been surpassed, the area under paddy was returned as nearly 3,750,000 acres. For the time being this

represented the high-water mark of the rice-growing industry in Cochin China. In 1914–15 the area under paddy was down to 3,361,000 acres. It is considered, however, that with the increase of population and the extension of land improvement works a very much larger area will be capable of growing rice—three times as large, it has been estimated, as the area hitherto brought under cultivation. Meanwhile the paddy fields form about nine-tenths of the total cultivated area (3,766,000 acres in 1914–15) and over one-fourth of the whole country. Only one crop is reaped annually, the harvest extending from December to March, with January and February as the chief harvest months. In 1914–15 the production was estimated at rather more than 2,000,000 tons of paddy, or 1,250,000 tons of cleaned rice. This is a good average crop. Comparatively, such a yield from an area of roughly 3½ million acres corresponds very closely with the acreage and yield in India in the same year (76,000,000 acres; 28,000,000 tons).

In Tonkin, which has an area of 46,000 sq. m. (29,500,000 acres) and a population (1911) of over 6,000,000, two crops of paddy are reaped in the year, and their cultivation is the chief occupation of the inhabitants of the deltaic region. It is stated (RUSSIER and BRENIER: *L'Indochine française*. Paris, 1911) that the paddy fields of the delta cover from 2,000,000 to 2,250,000 acres, and that another 250,000,000 acres could be brought under crop by irrigation. In 1907, according to the estimates of the provincial administrators, the first crop was reaped (May—June) from 1,151,000 acres and the second (October—November) from 1,719,000 acres; thus the total area reaped, reckoning each crop separately, was 2,870,000 acres. On the assumption that there had been no appreciable change in the cultivated area, and that the yield per acre averaged about the same as in Cochin China in 1914–15, the normal production in Tonkin in terms of cleaned rice might be put at nearly 1,100,000 tons. The actual output fluctuates greatly from year to year according to the incidence of floods and droughts and other vagaries of the season. Exports of all kinds of rice in the decade 1905–14 averaged about 160,000 tons, the remainder being required for local consumption.

In Annam, which lies between Cochin China and Tonkin, and which has an area of about 52,000 sq. m., with a population of over 5,000,000, the conditions of rice production are very variable. In the south, as in Cochin China, one crop per annum is reaped (January—February), while in the north, on the Tonkin side, two crops are obtained (May—June and October—November). In Central Annam the soil yields sometimes one and sometimes two crops (April—May and August—September). By comparison with Tonkin on a population basis, the requirements of Annam for local consumption might be estimated to be

equivalent to about 750,000 tons of cleaned rice. As Annam grows barely enough rice for its own needs, this estimate would imply a production of not more than 750,000 tons.

In the *Bulletin Economique de l'Indochine* (1910, **13**, 274) Cambodia was credited with having 1,670,000 acres under paddy, producing about 617,000 tons of paddy (385,000 tons of cleaned rice). The figures denote a lower average yield than in the neighbouring country of Cochin China, which from double the acreage gets a crop more than three times as large. Though covering an area of 45,000 sq. m., Cambodia has a population of only 1,634,000, and is able to export nearly half its relatively meagre crop.

The largest and most sparsely populated part of French Indo-China is the Laos territory (98,000 sq. m.; 640,000 inhabitants). Some years ago M. de Reinach, in his *Notes sur le Laos* (Paris, 1906), calculated that the total requirements of the population (then estimated at 500,000) for human consumption, for the feeding of live stock, for use in the manufacture of confectionery and intoxicants, and for seed, amounted to about 225,000 tons of paddy, or 140,000 tons of cleaned rice. The standard of living which this presupposes is not, however, by any means general, and, moreover, maize partly takes the place of rice in many parts of the country.

Altogether, the total production in Indo-China in a good average year may probably be put at about 3,500,000 tons of cleaned rice. It must be understood that this is only a tentative estimate based on very imperfect data. In the present year (1917) the total may have been between 3,500,000 and 4,000,000 tons, the crop in Cochin China and Cambodia being reported to be the best on record (about 1,850,000 tons).

The exports of rice from Indo-China, like the crops, are liable to big fluctuations. Since the beginning of the present century they have fallen as low as 612,000 tons in 1905 and risen as high as 1,406,000 tons in 1907. The general tendency of the returns, over a long period, has been strongly upward until the last few years. In the quinquennium 1886–90 the exports averaged 495,000 tons; in 1901–5 the average was 845,000 tons, and in 1906–10 it was 1,135,000 tons; in 1911–15 it remained practically the same—1,133,000 tons. These figures, which relate to the exports of rice of all kinds (paddy, cargo rice, cleaned rice, broken rice and rice meal) place French Indo-China in the front rank of rice-exporting countries, contesting with Siam for the next place to India. The different grades of rice are subject to various export duties which are in part preferential in favour of France and the French Colonies.

As already indicated, French Indo-China owes its importance as a rice-exporting country chiefly to Cochin China. Naturally enough, in view of the facts previously

given about the expansion of the rice-growing industry in that State, the export trade is largely the creation of the last half century—that is, the period during which France has exercised control there. In the early 'sixties considerably less than 100,000 tons of rice of all kinds were exported annually from Cochin China; in 1885, the first year for which returns were available for French Indo-China as a whole, Cochin China supplied about 455,000 tons out of a total of 493,000 tons; in 1915 it supplied 1,068,000 tons out of a total of 1,351,000 tons, the balance being provided almost entirely by Tonkin. It must be noted, however, that most of the exports from Cambodia pass through Saigon and are credited to Cochin China; it has been estimated that these average, at the present stage of development, about 150,000 tons. In one form or another rice provides about 75 per cent. of the exports from Saigon, both in weight and in value.

The total exports from Indo-China in 1915 were slightly less than in 1914 (1,397,000 tons), but were greater than in any earlier year except 1907. The greater part of the exports go to other countries in the Far East, and these countries were able to absorb most of the European trade which was dropped in 1915. The requirements of the Far Eastern countries themselves depend on the character of their own crops, and vary considerably from year to year; but a brief analysis of the export returns for 1913 may give some idea of the distribution of trade in a normal year. The total exports of rice of all kinds in 1913 amounted to 1,266,000 tons. Of this total France took 270,000 tons (171,000 tons of cleaned rice, the rest nearly all broken rice and cargo rice), or more than one-fifth. Exports to French colonies to the amount of 36,000 tons (nearly all cleaned rice) brought the movement of trade within the French Empire up to 306,000 tons, or nearly one-fourth of the total. Trade with European countries outside France was practically confined to the United Kingdom and Germany, which took in the one case about 44,000 tons, mostly of rice meal (*farines*), and in the other case about 49,000 tons, also mostly of rice meal. On the other hand the exports to Hong Kong amounted to 427,000 tons (mostly cleaned rice), or a full third of the total, while Singapore, the Dutch East Indies, the Philippines, and Japan took 414,000 tons (in each case consisting mostly or wholly of cleaned rice), or nearly another third of the total. As showing the variability of the different items of the trade, it may be noted that in 1915, though Singapore, the Dutch East Indies, the Philippines, and Japan again took a third of the total exports (which were greater than in 1913), the exports to Japan in the later year were practically nil, whereas in 1913 they accounted for 106,000 tons.

As will have been gathered from this brief analysis, the

great bulk of the exports consist of cleaned rice. In each of the years 1913, 1914, and 1915 the proportion was about three-fourths (about a million tons). Broken rice and rice meal compose most of the remaining exports. In Cochin-China rice milling is the leading industry next to rice growing. Milling for export is practically confined to Cholon (now almost a suburb of Saigon). Here, according to a recent U.S.A. Commerce Report (No. 78: April 4, 1917), ten large mills turn out annually over a million tons of rice of all grades valued at about £6,000,000, of which value perhaps one-fourth is contributed by the milling process. The rice required for local consumption is prepared in smaller mills.

Siam.—The rice grown in Siam provides not only the chief food supply of the people, but four-fifths of the total exports from the country in respect of value. Both local consumption and exports have increased greatly in the last few decades. In the British Consular report for 1890 it was estimated that an ordinarily good rice crop in Siam yielded rather more than 1,200,000 tons, of which about 700,000 tons were consumed in the country itself, leaving about 500,000 tons for export. Since then these figures have been more than doubled. Possibly insufficient allowance was formerly made for local requirements, but production has undoubtedly increased, as is evident from the growth of the export returns. These are subject to violent fluctuations, for owing to the small development of modern irrigation works—though plans for such works have been drawn up—the crops are very dependent on the seasonal weather conditions. In spite of intermediate setbacks, however, the Siamese export trade in rice has gone on from record to record until in thirty years it has quadrupled in weight. In 1884 the exports of rice of all grades reached a then maximum of 274,000 tons. The next advance was to 402,000 tons in 1887; in 1888 the amount was 450,000 tons, and in 1890 it was 480,000 tons. In 1892 the exports fell as low as 198,000 tons, but in the following year they rose as high as 776,000 tons. There was no improvement on this for nine years, though the lowest return in the interval was 415,000 tons. In 1902 a fresh record was established—798,000 tons, and every alternate year after that saw a further advance, until in 1908 the exports stood at 986,000 tons. In 1910–11 they reached 1,047,000 tons, but in 1911–12 there was a drop to 627,000 tons, and 1912–13 saw a further decline to 588,000 tons. All records, however, were surpassed again in 1913–14, when the exports totalled 1,174,000 tons, and up to the end of 1916 there had been little falling away from this high level.

The decennial averages over a period of fifty years show at a glance the rapid growth of the trade:

EXPORTS OF ALL GRADES OF RICE FROM SIAM

	Tons.
Average 1860–69	100,000
" 1870–79	155,000
" 1880–89	260,000
" 1890–99	460,000
" 1900–09	760,000

The quinquennium 1909–10 to 1913–14, though including the two years of reduced returns already mentioned, resulted in a further advance of the average rice exports to 878,000 tons.

As to the production which makes possible such exports, M. Petithuguenin, First Interpreter to the French Legation at Bangkok, in a study of the economic situation in Siam published in the *Bulletin Economique de l'Indochine* (1914, 17, 129), expressed the opinion that the home consumption of rice could not be less than about 1,200,000 tons without descending below starvation point, and estimated that it was actually over 1,700,000 tons. With exports in recent years averaging, say, 800,000 tons (exclusive of rice meal), this would give a production of about 2,500,000 tons. That is also the amount given by the American Vice-Consul at Bangkok as the usual output. According to the *Yearbook* of the United States Department of Agriculture for 1916, the production in 1913 was equivalent to 2,627,000 tons of cleaned rice, in 1914 to 2,550,000 tons, and in 1915 to 2,463,000 tons. On the other hand, American consular reports from Bangkok give the paddy crop in 1913–14 as 4,767,000 tons, and in 1914–15 as 4,626,000 tons. If the yield of clean rice from paddy be taken as five-eighths by weight (62½ per cent.), these two crops would be equivalent respectively to 2,980,000 tons of rice and 2,890,000 tons of rice. On a review of these various estimates it may be said that in an ordinary good year the Siamese rice crop is between 2,500,000 and 3,000,000 tons, and that about one-third of the crop is exported. The area under cultivation in recent years has been estimated at over 5,000,000 acres (5,181,000 acres in 1915–16). On the basis of these figures, the average yield per acre would be normally about 10 cwts.

As already stated, the export figures quoted above embrace all kinds of rice. The following is an analysis of the total for the latest pre-war year:

EXPORTS OF RICE AND RICE MEAL FROM SIAM IN 1913–14

Grades of Rice.	Tons.	Per cent.
White Rice	514,330	43·8
Broken White Rice	414,354	35·3
Cargo Rice	76,061	6·5
Broken Cargo Rice	9,505	0·8
Paddy	28,657	2·4
White Rice Meal	103,416	8·8
Cargo Rice Meal	27,657	2·4
Total	1,173,980	100·0

It will be seen that white rice and broken white rice formed 79 per cent. of the total exports, cargo rice and paddy only 10 per cent., and rice meal 11 per cent. As may be gathered from these figures, the milling of rice for export is an important industry in Siam. The mills for this purpose are established in and around Bangkok, through which city nearly the whole of the trade in rice passes. In 1916 it was reported that there were 53 rice mills in Bangkok and 5 in neighbouring towns. With two or three exceptions these were owned and worked by Chinese firms. According to the American Vice-Consul, paddy husk is furnished in sufficient quantities to provide fuel for all the local industries of Bangkok.

It is difficult to determine precisely the distribution of the exports, as the great bulk of them are shipped in the first instance to the entrepôts of Singapore and Hong Kong. In 1913–14 the exports (chiefly white rice) to Singapore were 426,989 tons (36 per cent. of the total), and the exports (chiefly broken white rice) to Hong Kong 461,236 tons (39 per cent.). Thus Singapore and Hong Kong together took 75 per cent. of the total. Among the exports consigned direct to Europe, Germany and Austria-Hungary took 95,441 tons (rather more than 8 per cent. of the total; Germany alone, 81,336 tons, or 7 per cent.), the Netherlands 76,058 tons (6·5 per cent.), the United Kingdom 49,656 tons, (4·2 per cent.), and Belgium 28,103 tons (2·4 per cent.)—altogether 21 per cent. out of the 25 per cent. not dispatched to Singapore and Hong Kong. Since the outbreak of war these two entrepôts have played a still larger part in the distribution of the Siamese rice exports. Out of total exports of 1,138,168 tons in the year 1916, Singapore took 622,641 tons (55 per cent.) and Hong Kong 409,784 tons (36 per cent.), or between them 91 per cent. of the total; while the exports to Europe direct amounted to only 67,055 tons (6 per cent.).

Netherlands East Indies.—Though producing more rice than either French Indo-China or Siam, the Netherlands East Indies support so large a population, particularly in Java, that they are numbered among the rice-importing countries. In Java and the adjoining island of Madura, which are almost exactly the same size as England and contain about as many people, nearly 45 per cent. of the area under cultivation in 1915 carried rice crops (6,940,000 acres out of 15,529,000 acres according to the *Statesman's Year Book* for 1917). Particulars of production in 1915 are not available, but the *Yearbook* of the United States Department of Agriculture gives the crop from 6,310,000 acres in 1913 as equivalent to 3,550,000 tons of cleaned rice, and from 6,346,000 acres in 1914 as 3,494,000 tons—an average yield of about 11 cwts. per acre. The remaining islands of the Netherlands East Indies, with an area over

thirteen times that of Java and Madura, are credited with about one-third the population. If their production of rice was proportionate, by population, to that of Java and Madura, their crops would amount to over 1,000,000 tons, and the rice production of the whole of the Netherlands East Indies might be estimated at over 4,500,000 tons. It may be doubted, however, if the "Outposts," as they are called, do grow rice on the same scale, even in relation to population, as Java and Madura. They are not nearly so highly developed agriculturally, and proportionately they are much heavier importers of rice. Possibly the total rice production of the Netherlands East Indies amounts to between 4,000,000 and 4,500,000 tons.

Though the Java rice crop is insufficient to meet local requirements, a certain amount of rice is exported. In the five years immediately preceding the war these exports averaged about 53,000 tons, and showed little variation from year to year. About half the rice exported goes to Borneo and China. Rice imports, on the other hand, averaged during the same period about 316,000 tons, and varied considerably from year to year, the minimum being 211,000 tons in 1909 and the maximum 484,000 tons in 1910. The supplies of rice from abroad are drawn almost entirely from Burma, French Indo-China, and Siam—principally the first two countries, though the distribution of trade is very variable. The following table is from the British Consular Report for 1913:

IMPORTS OF RICE INTO JAVA AND MADURA

Source of Supply.	1911. Tons.[1]	1912. Tons.[1]	1913. Tons.[1]
Rangoon	278,300	197,700	65,900
Saigon	62,000	16,000	144,000
Siam	49,000	21,200	44,000
Other countries	1,000	2,000	300
Total	390,300	236,900	254,200

[1] *Approximate.*

No exports of rice from the other Netherlands East Indian possessions are shown in the British *Statistical Abstract* for foreign countries, but these possessions (Sumatra, Netherlands Borneo, etc.) imported rice in the quinquennium 1908–12 to the average amount of 191,000 tons (minimum 142,000 tons in 1908; maximum 221,000 tons in 1911). Thus the annual requirements of the Netherlands East Indies as a whole in the way of rice from outside sources amount to about 500,000 tons.

Philippine Islands.—Of the area returned as under cultivation (nine principal crops) in the Philippines in 1913–14, rice was grown on nearly half (48 per cent.). It is not

a proportionately valuable crop, and the amount of rice produced from year to year is influenced by the demand for labour in other directions, as well as by the weather conditions. The liability of the crop to serious damage from typhoons, droughts and floods is a serious check on development. Comparatively little has been done at present to control the effect of the climatic conditions by irrigation. In an official pamphlet, *Rice Culture in the Philippines* (Manila, 1912, *Bulletin* 22), it was stated that only about 125,000 acres were under irrigation, though the area easily irrigable was at least 1,200,000 acres. An active policy of extension is being pursued by the Irrigation Division of the Bureau of Public Works, and in the pamphlet quoted it was anticipated that within a very few years many thousands of acres which had hitherto remained idle would be producing good crops of rice. In other ways much enterprise is being shown by Government with the objects of extending cultivation and improving the average yield. The Agricultural Department has been engaged for several years in selecting the best kinds of rice out of the large number grown (according to *Bulletin No.* 22, something like 1,300 names have been recorded and 910 more or less distinct varieties have been collected and tested). With scientific research are combined popular educational methods, such as the issue of posters giving advice to farmers and the dispatch of a rice demonstration train through the principal rice-growing districts. As in Japan, cultivation is mostly on small holdings. Writing in the *Philippine Agricultural Review* (1916, 9, 61), the Director of Agriculture stated that 50 per cent. of the farmers work less than 2½ acres, that nearly 90 per cent. work less than 12½ acres, and that only a fraction of 1 per cent. work over 250 acres. Four-fifths of the rice grown is transplanted, and non-glutinous white rice constitutes about 75 per cent. of the total production. It is claimed by the Director of Agriculture that a comparison of the crops in two years enjoying fairly normal weather conditions, 1906 and 1913, shows an increase of production during the interval of 40 per cent., due to the increase in the average yield. The educational propaganda which is carried on by the Agricultural Department should certainly bear fruit in this direction; but even now, as is admitted, the yield is extremely low. In the quinquennium 1911–15, the area under rice cultivation increased steadily from 2,579,000 acres in 1911 to 3,076,000 acres in 1914, but declined in 1915 to 2,794,000 acres. During the same period the crops, expressed in terms of cleaned rice, ranged from 320,000 tons (1912) to 675,000 tons (1913). Both in 1912 and in 1915 (491,000 tons) there were partial crop failures; the average for the other three years was 623,000 tons. It will be seen that at its best the crop averages only between

4 and 5 cwts. per acre, which is not much more than half the average yield in British India.

As a result of this low yield, the Philippine Islands are heavy importers of rice. Exports are negligible (2 tons in 1913, 35 tons in 1914, 17 tons in 1915). Imports, from 1899, when the islands were ceded to the United States, up to and including 1915, averaged not far short of 200,000 tons, reaching their maximum in 1903 (over 300,000 tons) and their minimum in 1913 (85,600 tons). In 1914 they were 95,400 tons, and in 1915 they were 215,000 tons. French Indo-China supplies about 90 per cent. of these imports (204,500 tons, or 95 per cent. in 1915) and Siam most of the remainder (7,300 tons in 1915).

Asiatic Russia.—Though Asiatic Russia is not among the great rice-producing countries, there is a considerable quantity of rice grown in Russian Turkestan. According to M. Woeikof's *Le Turkestan Russe* (Paris, 1914) the area under rice-cultivation in that country has largely increased since the Russian conquest. Formerly the cultivation of rice was confined to natural rice lands, and the rice fields were not allowed water from the irrigation canals till other crops had been served. After the Russian conquest these restrictions ceased to be observed, with the result that in Samarkand and Katta Kurgan the area under rice increased from 27,000 acres in 1869 to about 50,000 acres in 1875, while in 1900 there were 106,000 acres growing rice in Samarkand alone. The following particulars of acreage and crop in three provinces in 1909 are given by M. Woeikof from the returns of the Russian Central Statistical Committee:

RICE CULTIVATION IN RUSSIAN TURKESTAN

	Acres.	*Tons.*
Syr-Daria	176,000	88,000
Ferghana	181,000	86,000
Samarkand	136,000	64,000
	493,000	238,000

In the report on the British consular district of Batum for the year 1914, the Vice-Consul at Baku, referring to the agricultural products of "Transcaspia," gives the rice crop as approximately ten million poods (about 160,000 tons). It is obvious from this and other returns given by the Vice-Consul that the reference is not merely to the sparsely populated Trans-Caspian Province, and presumably the estimate embraces Russian Turkestan.

The corresponding consular report for 1913 contains the following particulars of the two principal rice-growing districts in Transcaucasia:

RICE CULTIVATION IN TRANSCAUCASIA

District.	1912. Acres.	1912. Tons.	1913. Acres.	1913. Tons.
Geokchai	—	6,000	—	6,000
Linkoran	40,770	36,000	41,120	31,000
		42,000		37,000

It is possible that the estimates of production quoted by M. Woeikof for Turkestan (equivalent to an average yield of nearly 10 cwts. per acre), and by the British Vice-Consul at Baku for the Linkoran district of Transcaucasia (equivalent to an average yield of nearly 18 cwts. per acre in 1912 and 15 cwts. per acre in 1913) are in terms of rough rice, or paddy. The *Yearbook* of the United States Department of Agriculture gives the production of cleaned rice in Transcaucasia and Turkestan in 1912 as 124,000 tons from 491,000 acres (5 cwts. per acre); in 1913 as 229,000 tons from 668,000 acres (7 cwts. per acre); and in 1914 as 170,000 tons from 636,000 acres (5 cwts. per acre). Bokhara and Khiva are not included in these estimates. Their addition might bring the total rice production of Russian Western Asia, on the basis of the estimate of the United States Agricultural Department, to about 200,000 tons in an ordinary year, rising in a good year to over 250,000 tons.

Production is not equal to consumption, and rice is imported in considerable quantities, chiefly from the Caspian provinces of Persia. The extent of the Persian trade will be seen from the following section.

Persia.—Rice enters largely into the diet of the Persian people. It is grown in most of the provinces, in places where there is natural swamp land or a sufficiency of water to inundate the fields. Such places are not very numerous or extensive in the high, dry plateau region of the interior. Among them may be mentioned the neighbourhoods of Shiraz and Isfahan. But the great bulk of the rice produced in Persia is grown in the low-lying, humid country adjoining the southern coast of the Caspian Sea, comprising the provinces of Gilan, Mazandaran, and Astarabad. Rice is there a staple crop and constitutes the staple food of the people. Practically the whole of the rice exports of Persia come from that quarter, and considerable quantities are also sent to other parts of Persia.

A small quantity of rice is imported, chiefly into the south of Persia from India, but the exports which are dispatched from the Caspian ports into Russian territory, and which find their principal market in Baku, are on a much larger scale. In 1914–15 the exports were three times as valuable as the imports, and usually, in the past, the proportion has been much higher. The following table gives the returns for five years:

	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.
Imports .	£62,000	£66,000	£96,000	£159,000	£117,000
Exports .	£531,000	£632,000	£769,000	£766,000	£356,000

In the six years 1906-7 to 1911-12 imports ranged from 1,392,000 batmans (1906-7) to 2,718,000 batmans (1909-10), *i.e.*, if the batman be taken as the Tabriz batman of 6½ lb., from about 4,000 tons to 8,000 tons. In the same six years exports ranged from 16,809,000 batmans (1907-8) to 24,054,000 batmans (1911-12) or from about 49,000 tons to 70,000 tons. Usually about 75 per cent. of the exports consist of husked rice. About 80 per cent. of the total are furnished by the province of Gilan, and most of the remainder by Mazandaran, which also sends large quantities to the Teheran markets. Generally speaking, it is the inferior and medium qualities of rice which are exported to Russia. A considerable part of the exports, especially the lowest grades, are used in the manufacture of starch for dressing light cotton goods.

Production and trade have both undergone considerable development in the last half century. A consular report on Gilan for 1892-3 spoke of the exports of rice as having made great strides since the 'seventies, and ten years later (1903) it was noted that "a prodigious quantity of timber has been felled during the past thirty years to make room for rice fields and plantations of dwarf mulberry trees." In an elaborate monograph, *La Culture du Riz en Guilan (Perse) et dans les autres provinces du sud de la Caspienne*, by MM. Rabino (formerly British Vice-Consul) and Lafont, reprinted from *Annales de l'Ecole nationale d'Agriculture de Montpellier* (Montpellier; 1911), a list of the annual exports of rice from the Caspian provinces showed a fairly steady progression from 38,000 tons in 1901-2 to 59,000 in 1908-9, and in 1911-12, as already noted, exports had further increased to 70,000 tons. Previously a consular report had returned the exports in 1895 as 43,000 tons, and the Hon. George Curzon (now Earl Curzon of Kedleston), in his work on Persia published in 1892, quoted an estimate which put the exports of rice from Gilan and Mazandaran to Russia even in those days at 58,000 tons per annum. M. Rabino, however, regards the latter estimate as an exaggeration. With modern irrigation works and better cultivation the present output might be much increased.

Data are lacking for any estimate of the production of rice in Persia as a whole. M. Rabino, in the monograph previously quoted, estimated the annual consumption in Gilan at 128,000 tons, and as the exports from Gilan in 1908-9 were 41,000 tons to Russia and 6,000 tons to the interior of Persia, he arrived at a total production of rice in that province in that particular year of 175,000 tons.

Mesopotamia.—Before the war, paddy formed about one-sixth of the grain harvest. A record crop in 1911 was estimated at 48,000 tons of paddy (30,000 tons of cleaned rice).

Production varied greatly; with a proper irrigation system it might be steadied and much increased. Basra exported considerable but irregular quantities of paddy (estimated at 65,000 tons in 1912, from accumulated stocks; usually under 25,000 tons; only 3,000 tons in 1913, when the crop failed), and much smaller quantities of rice (usually two or three thousand tons; only 16 tons in 1913). These exports went chiefly to the United Kingdom and Germany for distilling and sizing purposes, the quality being inferior. Basra also did a small import trade in rice from India (normally from 1,000 to 2,000 tons; in 1913, 8,000 tons). Asiatic Turkey as a whole offered a large market for rice, taking about 80,000 tons a year from India.

Madagascar.—For centuries rice has been the staple food crop in this French colony, especially in the central and eastern provinces. "Carolina" rice is said to have been first imported into America from Madagascar at the end of the 17th century. The best rice fields are in the neighbourhood of the capital, Antananarivo, to the west of which the great marshy plain of Betsimatatra is devoted to the production of rice. Cultivation, however, is widespread, and is capable of much greater extension. Many varieties are grown; they may be divided broadly into two classes, white and red rice.

Many years before the French occupation in 1895, the crops were not only meeting local needs, but providing a surplus of some thousands of tons for export. There set in, however, a period of decline in cultivation, except in Imerina (the country round the capital) and among the Betsiléo (in the south central provinces), where irrigation systems of a very ingenious character have been developed by the natives. The unsettled conditions which attended the French conquest intensified the decline, and crops were also badly damaged in successive years by ravages of locusts. Thus for a time crops fell below consumption, and in 1901 the imports of rice amounted to as much as 25,000 tons. With the return of more settled conditions, recovery was rapid. In 1908 rice was exported to the amount of 4,600 tons, and though there was some ebb and flow later, exports were continuous and amounted in 1915 to 19,000 tons. In the latest pre-war year, 1913, they amounted to 10,500 tons, of which 1,460 tons were paddy. About 30 per cent. were consigned to France, 40 per cent. to French Colonies, and over 20 per cent. to British colonies. As communications are improved and new rice mills erected, further developments of production and trade are anticipated. The Comoro Islands, which used to import Indian rice from Zanzibar, now draw their supplies almost entirely from Madagascar, and the hope has been officially expressed (*Bulletin de l'Office Coloniale*, 1916, **9**, 471) that in a few years Réunion and Mauritius will also be able to supply

their needs from Madagascar. In South Africa there is said to be an increasing demand for Madagascar rice.

According to the *Bulletin Economique de Madagascar* (1909, **9** (i), 68), the area under rice cultivation in 1908 was estimated at 875,000 acres. Allowing for an average yield of 16 cwts. of paddy (10 cwts. of cleaned rice) per acre, the total production was estimated at about 700,000 tons of paddy (440,000 tons of cleaned rice).

Portuguese East Africa.—Rice is one of the native food crops, though in the Zambezi valley, at any rate, Mr. Consul Maugham notes in his book *Zambezia* (Murray, 1910) that it "is only found in large areas near the coast." It is grown by the "prazo" companies—companies to whom the native tax is farmed out—and in the Government reserves of Quelimane, but is essentially a native crop (R.N. Lyne's *Mozambique*; Fisher Unwin, 1913). Samples have been imported and distributed for experimental purposes from Dar-es-Salaam, Burma, Bengal and Ceylon. In 1913 nearly 7,000 tons were imported, chiefly through Beira and Lourenço Marques.

German East Africa.—Before the war the cultivation of rice by the natives was being widely extended, and it was anticipated that the Central Railway (Dar-es-Salaam to Lake Tanganyika) would open up fresh tracts of rice-producing country. Aquatic rice is chiefly grown, and the supplies are mostly consumed in the country; exports, which go principally to Uganda, amounted to 590 tons in 1911 and 900 tons in 1912. The Muansa district (round the southern shores of the Victoria Nyanza) is the main rice-producing and exporting area. There were also 1,165 acres under rice cultivation by Europeans in 1912, and the results were said to be satisfactory. Production is not, however, equal to consumption, and in 1913 there were imported 15,735 tons of rice, against 13,213 tons in 1912 and 17,330 tons in 1911. The imports were almost entirely from India. The native rice is said to be at least of as good quality as the imported.

Belgian Congo.—According to Sir Harry Johnston (*George Grenfell and the Congo*; Hutchinson, 1908), though there is a kind of wild rice, *Zizania*, of poor quality, apparently indigenous to the rivers of the northern Congo basin, rice was practically unknown in the central basin until the German explorer, Dr. Pogge, introduced it in 1875 or 1876. About the same time the Zanzibar Arabs introduced rice into the Eastern Congo. To-day it is widely grown, not only in the Central Congo basin, but along the Upper Congo River and parts of the Lomami. Between Kasongo and Stanley Falls, especially, where the Upper Congo flows through park-like or even treeless country, large quantities of rice are grown. It is only quite

recently, however, that production has overtaken consumption. In 1913 only a little over 3 tons of rice were exported, whereas imports amounted to 4,430 tons. In 1915 imports had dropped to 643 tons and exports amounted to 1,122 tons. In 1916 the Stanleyville region alone produced over 5,000 tons, and it has been estimated that by 1918 the total rice crop will, after meeting local requirements, leave an exportable surplus of over 15,000 tons.

French Equatorial Africa.—Rice cultivation is of comparatively recent introduction and has been little developed. The coast region of Mayombé is believed to be particularly well adapted to this branch of agricultural industry. In 1913 the colony of the Gabun imported about 1,000 tons, and the Middle Congo and Ubangi colony about 500 tons.

French West Africa.—The position in regard to rice in the French West African colonies—Senegal, Upper Senegal and Niger, Guinea, Ivory Coast, and Dahomey—is much the same as in the British West African colonies: rice is widely cultivated, and in some districts attains considerable importance, but production is not equal to consumption, and there is a moderate import trade. Cultivation is practised especially along the banks of the Niger, in the Casamance district of Sengal (south of the Gambia colony), and in French Guinea, where it is grown not only in the coastal districts, but in the Futa Jallon highlands. A Government experimental station has been established in Guinea, and private enterprise has erected a milling plant on the middle Niger. Imports in 1913 amounted to about 20,000 tons, Senegal importing about three-fourths of the total and the Ivory Coast nearly one-fifth. France is the chief source of supply. Exports are a negligible quantity.

Liberia.—Rice is an old established crop in this country. It is largely grown by the natives throughout the hinterland, but not in sufficient quantities to meet the demand. According to Sir Harry Johnston (*Liberia*; Hutchinson, 1906), the annual imports amount to about 700 tons.

United States.—In 1916 the area under rice cultivation in the United States was 866,300 acres, and the crop was officially estimated at 520,600 tons. This was about 45 per cent. in advance of the 1915 crop, itself the highest then on record. The increase is accounted for partly by the increased area under cultivation, but mainly by the greater average yield, which was as much as one-third more than in 1915. Following are the returns for five years:

Year.	Acreage.	Cleaned Rice. *Tons.*	Average Yield. *Cwts. per acre*
1912	722,800	310,700	8·6
1913	827,100	319,200	7·7
1914	693,500	293,300	8·5
1915	802,600	359,000	8·9
1916	866,300	520,600	12·0

It will be seen that until last year the average yield was not greatly in excess of that obtained in India.

Formerly the chief rice-growing States were the Carolinas and Georgia, but in the last forty years these have sunk into insignificance in respect of both cultivation and production, and the three great rice States now are Louisiana, Texas and Arkansas. In these Gulf States are extensive areas specially suited to the crop alike by the nature of the soil and by facilities for irrigation. Louisiana alone had a larger acreage under rice in 1916 than all the other States in the Union put together. The distribution of cultivation and production in 1916 is shown in the following table:

State.	Acres.	Percentage of area.	Percentage of crop.
Louisiana	443,300	51·2	50·1
Texas	235,000	27·1	26·0
Arkansas	125,000	14·4	15·5
California	55,300	6·4	8·0
Other States	7,700	0·9	0·4
Total	866,300	100·0	100·0

Though doing a variable export trade in home-grown rice, the United States has hitherto required to import rice and rice products on a much larger scale. The balance of trade on the import side was, however, much reduced in 1915–16, as will be seen from the following returns for the quinquennium ending with that year:

U.S.A. TRADE IN RICE AND RICE PRODUCTS

	1911–12. *Tons.*	1912–13. *Tons.*	1913–14. *Tons.*	1914–15. *Tons.*	1915–16. *Tons.*
Imports	84,800	99,200	129,600	123,700	118,000
Re-exports	4,600	5,700	7,900	26,400	32,050
Net imports	80,200	93,500	121,700	97,300	85,950
Domestic exports	17,600	17,400	10,000	34,600	54,450
Balance of imports over exports	62,600	76,100	111,700	62,700	31,500

The imports, though fluctuating considerably, have shown a decided tendency to increase over a long series of years. Forty years back, in the quinquennium 1872–6, they averaged 34,400 tons, against an average of 111,000 tons in the quinquennium for which returns are given in the preceding table. In the United States trade statistics the imports of rice are classified under three heads—"cleaned," "uncleaned, including paddy," and "rice flour, rice meal and broken rice." There has been a striking change in the last five years in the proportions in which these different classes of rice figure in the returns. While the imports of cleaned rice have rapidly increased, and there has been a

considerable though less marked increase in the imports of uncleaned rice, the imports of rice meal, etc., have declined. In 1911–12 broken rice and meal formed 61 per cent. (52,000 tons) of the total imports, uncleaned rice 26 per cent. (21,600 tons), and cleaned rice only 13 per cent. (11,200 tons). In 1915–16 the order was reversed: cleaned rice (54,030 tons) formed 46 per cent. of a larger total; uncleaned rice (39,140 tons), 33 per cent.; and broken rice and meal (24,830 tons) only 21 per cent. The chief countries of supply are China, the United Kingdom and the Netherlands for cleaned rice; Japan for uncleaned rice; and the Netherlands, the United Kingdom and China for broken rice, flour and meal.

While the imports of cleaned rice have been increasing, re-exports of the same product have also been increasing. The rice exported from the United States under the head of foreign merchandise consists almost entirely of cleaned rice (over 98 per cent. in 1915–16, and an even larger proportion in previous years). Thus the sudden large increase in the re-exports in 1914–15 and 1915–16 has affected in particular the net imports of cleaned rice. These, however, still remained at the end of the quinquennium 1911–12 to 1915–16 considerably higher than at the beginning. The following are the figures for the imports and re-exports of cleaned rice only:

CLEANED RICE

	1911–12. Tons.	1912–13. Tons.	1913–14. Tons.	1914–15. Tons.	1915–16. Tons.
Imports	11,200	14,600	42,600	50,050	54,000
Re-exports	4,600	5,600	7,900	26,400	31,400
Net imports	6,600	9,000	34,700	23,650	22,600

The re-exports are distributed mostly through Central and South America and the West Indies.

Exports of home-grown rice and its products from the United States fall into two categories in the trade returns—"rice" and "bran, meal and polish." The latter class of exports is now quite insignificant; nearly 99 per cent. (53,880 tons) of the combined exports in 1915–16 consisted of "rice." Here, as in the case of the rice imports, there has been a complete change in the character of the trade in recent years. In 1911–12 bran and polish formed 32 per cent. (5,640 tons) of the combined exports, and in 1905–6 as much as 90 per cent. (15,260 tons). The normal amount of the total exports was between 10,000 and 20,000 tons till the sudden advances of 1914–15 and 1915–16. In one earlier year, however, the exports were little short of the total in 1915–16, having amounted in 1904–5 to over 50,000 tons. Before the war practically all the exports of bran and polish went to Germany. Of the exports of rice, Europe (chiefly the Netherlands, the United Kingdom and Germany) used to

take from one-half to two-thirds; but both in 1913–14 and in 1914–15 the greater part of these exports went to the Central American and West Indian Republics, especially Cuba.

Central and South America.—Rice is already grown in considerable quantities in the countries of Central and South America, and its cultivation is capable of great extension. At present production is not equal to consumption. None of the republics but Brazil has yet developed, on balance, an export trade in rice, and it has been estimated (*Bull. Pan-American Union*, February 1917) that the total imports, including those into Cuba, the Dominican Republic and Haiti, had an annual value according to the latest returns of between £3,000,000 and £4,000,000. The imports into Cuba (143,000 tons in 1915) accounted for half the total value. After Cuba the chief importing countries are Argentina (42,000 tons of rice, 17,000 tons of paddy, in 1913) and Chile (21,000 tons in 1915), these two countries together taking nearly one-fifth of the total imports by value.

Data are lacking for a complete estimate of production. From such crop returns as are available it may be said that production in general is not on a large scale, that of Brazil being probably in excess of the production of all the other republics in Central and South America.

In Mexico the crop in 1914 was estimated at about 15,000 tons of cleaned rice. The chief areas of rice cultivation are in the Pacific Coast States of Colima, Guerrero, and Michoacan, the Gulf State of Tabasco, and the inland State of Puebla—all in Southern Mexico. Production falls little short of consumption, the imports in 1911–12 being only about 1,300 tons.

In Guatemala the rice crop of 1916 was estimated at about 7,500 tons. In the previous year it had been returned as 10,700 tons. Salvador had a crop of about 5,500 tons in 1914, and Honduras nearly 1,500 tons in 1915. Costa Rica, which with 7,000 acres under rice cultivation in 1914 might have perhaps normally a crop of about 2,000 tons, imported 2,300 tons in 1914 (over half from Germany). Nicaragua imported 2,300 tons in 1915 (all from the United States) and Panama 4,500 tons in the first half of 1914, chiefly from the United States and Germany.

Dutch Guiana produced over 2,000 tons of cleaned rice in 1913 and 3,000 tons in 1914. An anticipatory estimate of the 1917 crop in Ecuador placed it at 15,000 tons.

In Peru, which is perhaps the country of largest production in South America next to Brazil, the crop in 1913, according to the *Yearbook* of the United States Department of Agriculture, was 48,600 tons of cleaned rice from 138,000 acres (7 cwts. per acre). From other estimates this would seem to be rather above the average. Rice cultivation is the staple industry in Lambayeque and La Libertad (two coast

departments with an abundant water supply), where about 60,000 acres are cultivated. The land is not manured, and after being cropped is allowed to lie fallow. The rice is of excellent quality, and some of it is exported, but not to the extent of the imports.

Rice growing in Brazil is mentioned in some of the earliest records of European settlement. It declined for a time in the second half of last century, when coffee was introduced, and in 1902 production had fallen so far below consumption that the imports amounted to about 100,000 tons. Energetic measures (including the establishment of heavy import duties) were taken to restore the balance. The Ministry of Agriculture, Industry and Commerce has encouraged the introduction of new varieties and modern methods. Cultivation generally is still rather primitive, but has extended rapidly. Japanese immigrants have taken up the industry, among other branches of agriculture. An estimate covering the south-eastern States of Minas Geraes, São Paulo, Rio Grande de Sul, Rio de Janeiro, and Santa Catharina gave a production equivalent to about 210,000 tons of cleaned rice. São Paulo is the only State for which regular crop estimates are available. From returns given in *United States Commerce Reports* (No. 273, September 18, 1917) the yield of cleaned rice in that State in the last six years works out as follows: in 1912, 64,000 tons; in 1913, 51,000 tons; in 1914, 54,000 tons; in 1915, 37,000 tons; in 1916, 72,000 tons; in 1917, 72,000 tons. In Brazil as a whole not only has production overtaken consumption, but this year (1917) the United States Consul-General reports a considerable export trade (20,000 tons in the first six months; whether paddy or rice is not stated), chiefly with France and Argentina.

In Argentina also the Government, with the aid of a Japanese expert, has been seeking to develop rice-growing along progressive lines. The results, however, hitherto have been inconsiderable. Production is said to have more than doubled between 1911 and 1916; but the area under cultivation was returned at the census of 1908 as 20,000 acres, and there can have been no great extension in the interval, since according to a United States *Commerce Report* (January 9, 1917) production in 1916 was under 7,000 tons, drought being responsible for the loss of about one-third of the crop. There remains in Argentina a desire to make that country independent of outside sources of rice supply. Fifty per cent. (21,000 tons) of the rice imports in 1913 were from Italy, the imports from British possessions amounting to only 4,700 tons; but British possessions supplied over 40 per cent. (7,250 tons) of the total imports of paddy. Of the imports into Chile in 1915 India supplied over one-third (7,670 tons).

As regards future developments, some of the most

promising fields for the extension of rice-growing on a large scale in South America are to be found "in the vast reaches of level lands in Brazil; in the Pacific Coast sections of Peru and Ecuador; in the northern lowlands of Colombia, Venezuela, and the Guianas; and in the extensive and fertile plains of northern Argentina" (*Bull. Pan-American Union*, February 1917).

Table of the World's Rice Crops

In the following table are gathered together the conclusions reached in the preceding investigation of rice production in the different rice-growing countries. The chief omission is China. For most of the other leading countries official estimates are available, and in such cases the year to which the estimate relates is given in brackets after the name of the country. In other cases the estimates are of normal production, and the reader is referred to the various sections for the data on which they are based. The totals, being composed of valuations of a heterogeneous character, are useful only as affording a general idea of the magnitude to which the world's production of rice (outside of China) has attained.

Country.	Production (cleaned rice). Tons.
India *:	
British India (1916–17)	34,079,000
Native States	1,000,000
Ceylon † (1915)	172,000
Malaya †:	
Straits Settlements	35,000
Federated Malay States (1913)	46,000
Kelantan	35,000
Perlis	7,000
British North Borneo † (1914–15)	9,800
Hong Kong †	15,000
Fiji †	9,000
Egypt † (1914–15)	366,000
Uganda †	100
Nyasaland (1916)	1,300
British Guiana * (1915)	41,000
Trinidad †	1,700
British Countries (approximately)	35,818,000
Italy * (1916)	320,000
Spain * (1916)	149,000
Bulgaria † (1912)	3,000
Greece †	1,200
European Russia † (1913)	250
Transcaucasia and Russian Turkestan † (1914)	170,000
Bokhara and Khiva †	40,000
Persia *	250,000
Mesopotamia *	30,000
Siam *	2,500,000
Netherlands East Indies †:	
Java and Madura (1914)	3,494,000
Sumatra, etc.	750,000
French Indo-China *	3,500,000
Japan (1916)	8,177,000
Korea * (1916)	1,758,000
Formosa * (1914)	647,000
Philippines † (1915)	491,000
Madagascar *	450,000
United States † (1916)	520,600
Mexico † (1914)	15,000
Guatemala † (1916)	7,500
Netherlands Guiana † (1914)	3,000
Ecuador † (1917)	15,000
Peru † (1915–16)	40,000
Brazil *	250,000
Argentina † (1916)	7,000
Foreign Countries (approximately)	23,589,000
World's Total (for countries listed)	59,407,000

The preceding table distinguishes between: (1) countries (marked *) in which, normally, production exceeds consumption. These are the mainstay of the rice export trade. India, Korea, Formosa, Persia, and Mesopotamia, besides contributing, in very different degrees, to this trade, import considerable quantities of rice for home consumption. (2) countries (marked †) in which, normally, consumption exceeds production. Java, the United States, and Egypt, while large importers of rice for home consumption, do a considerable export trade in home-grown rice. Owing to recent crop developments in Japan it is doubtful, pending receipt of fuller trade returns, to which category that country now belongs.

Preparation of Rice for the Market

The rough rice (paddy) as it leaves the thresher consists of the fruit or grain, comparable with the wheat grain, surrounded by a closely enveloping scaly bract, known botanically as the palea or, more generally, as the husk, hull or shude. The grain itself, like other grass fruits, is composed of an outer skin, which consists of the fruit wall (pericarp) and seed coat (testa) fused together, enclosing, except at one end where the germ or embryo is situated, a layer of cells rich in proteins and known as the aleurone layer, within which, and forming the bulk of the grain, is the starchy portion of the endosperm. The latter is white in the ordinary rice of commerce, and in order to obtain a product of good appearance and of better cooking quality, the germ and outer brownish layers, together with the husk, are removed by milling.

In the native method of milling the paddy is pounded by means of a pestle and mortar, worked either by hand or by machinery. The husks are thus broken, and a portion both of the outer layers of the grain and of the germ is removed. The husks and dust are then separated from the grain by winnowing. Before being cooked the grains are submitted to a further pounding in order to remove the remainder of the outer layers and germ and so obtain a cleaned product. The percentage yields of the various products in one case of hand-pounding noted in Burma were as follows: cleaned whole rice 57·4, broken rice 10·1, meal and dust 13·3, husk 19·2 (*Burma Department of Agriculture, Bulletin* No. 10, 1913).

In modern rice mills the paddy is treated by elaborate power-driven machinery, the process consisting of either four or five stages, viz.:

1. Sifting and winnowing,
2. Hulling,
3. Skinning,
4. Polishing,

   and sometimes

5. Coating or facing.

(1) *Sifting and winnowing.*—The paddy is freed from dirt and other foreign matter.

(2) *Hulling.*—The clean paddy is passed through milling-stones or a series of hullers, screens and winnowing machines in order to remove the husks. In this process a certain amount of dust, known as "mill dust," is produced, consisting largely of husk-fragments, together with some rice skin and a little starch.

(3) *Skinning.*—The husked rice is milled in cones to produce "skinned" or "white" rice (known in Burma as "loonzein"). During this process the skin is removed with much of the aleurone layer, and also the germ, and these together constitute "rice bran or meal." The term "rice meal" is also used to designate a product consisting of the "rice bran" mixed with the "rice polish" (polished meal) produced in the next stage of milling.

(4) *Polishing.*—The "skinned" rice is passed through a polishing machine, consisting of a cylinder made of wood and wire-gauze in which revolve rollers covered with sheep-skin or pig-skin. These rollers remove the remainder of the aleurone layer and any adhering floury matter from the grain and give it a smooth surface. The matter removed by polishing is known as "rice polish."

In the three stages of hulling, skinning and polishing a certain amount of broken rice is produced, and this is usually graded and sold separately.

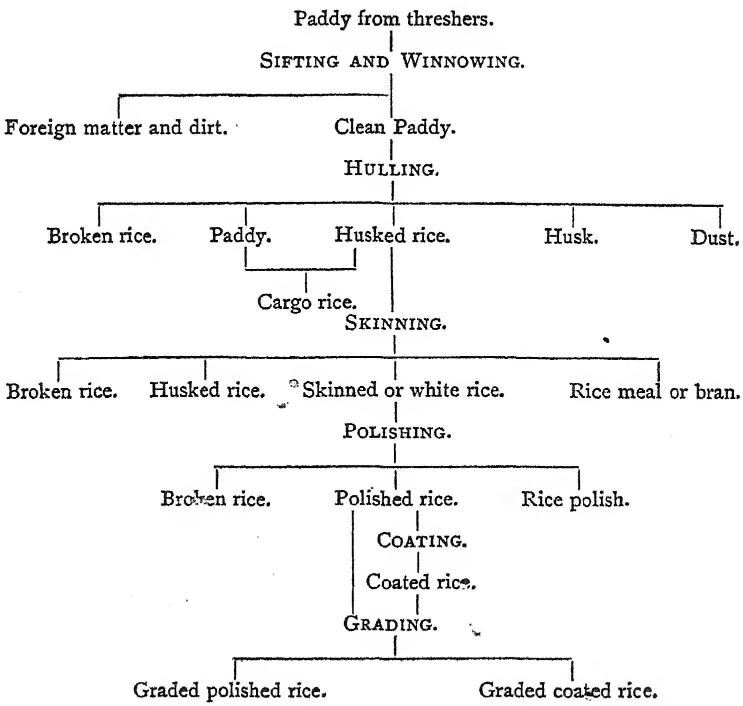
(5) *Coating or facing.*—Further to improve the appearance of the rice for commercial purposes, powdered talc (or alternatively steatite), colouring matter and oil are used for the respective purposes of imparting a more lustrous surface, a desired colour effect, and a translucent appearance. Other materials have been tried in place of talc, *e.g.* powdered mica, kaolin and gypsum. The talc is usually mixed with glucose, glycerine and starch paste, and sometimes also with mineral oil. In some mills talc and ground rice are previously added to the grain while it is passing through the mills. In any case the glazing mixture supplies the polished rice with most of its mineral surface, the addition varying from 0·15 to 0·44 per cent. in English mills, and from 0·16 to 2·00 per cent. in foreign mills. The colouring material, in the form of a powder—usually a blue pigment (ultramarine, Prussian or aniline blue) in order to counteract the milky whiteness of the rice—is generally mixed with the rice after milling and before polishing. The amount of pure pigment varies, but in many cases about 0·013 lb. of ultramarine is added to 1 ton of rice. The oiling material—generally a mineral oil—is added to produce a translucent effect only when no glaze has been used, and is then added after the milling. The amount of oil used is about 0·3 gallon to the ton. In England no limit as to the

quantity of talc employed for coating rice has been laid down by law, and it is left to the consumer to take action under the Sale of Food and Drugs Act.

In a report made to the Local Government Board, Dr. Hamill points out that 0·5 per cent. of added mineral matter would appear amply to meet the requirements of traders who regard this practice as necessary.

In the United-States the use of talc is permitted, provided that each package is plainly labelled with the name of the preservative and that proper directions for its removal be given. The Department of Agriculture, who administer the United States Food and Drugs Act, have decided that rice coated with glucose and starch must be labelled to that effect, and in no case may a coating of any kind be applied if it has the effect of concealing damage or inferiority.

The various stages of milling and the products at each stage are shown in the following diagram:



Large quantities of "cargo rice," consisting of incompletely husked rice in which a certain amount of paddy remains, are shipped from the producing countries, mainly to Europe, where the milling is completed. The proportion of paddy in "cargo rice" varies from 5 to 20 per cent.

The following figures show approximately the outturn of the various products in the case of Burmese mills,

according to experimental investigation by the Burma Department of Agriculture:

	Per cent.		Per cent.
Polished rice . .	44·0	Meal and polish . .	8·8
Broken rice . .	24·0	Husk	20·0
Dust	3·2		

In the United States the average yields in trials made with rices of the Honduras and Japan types were as follows:

	Honduras type. Per cent.	Japan type. Per cent.
Cleaned rice (whole and broken) . .	62·3	65·4
Meal	13·6	12·3
Polish	3·7	3·7
Husk and milling loss	20·4	18·6

Composition of Rice and the By-Products of Milling

The percentage composition of unhusked rice and of the products obtained at the different stages in the United States is shown in the following table. (*Bulletin No.* 330, 1916, *United States Department of Agriculture*):

Description of Rice and By-products.	Percentage Organic Composition. Moisture.	Fat.	Proteins.	Carbohydrates (by difference).	Crude fibre.	Ash.
Honduras type.						
Unhusked rice (1)	11·27	1·58	7·48	65·6	8·67	5·40
Husked rice (1) .	12·32	1·79	8·57	75·15	0·99	1·18
Skinned rice (1) .	12·50	0·28	7·88	78·57	0·30	0·47
Polished rice (1) .	11·89	0·25	8·06[1]	79·14	0·30	0·36
Meal (2) . .	9·61	10·65	13·41	44·04	11·71	10·58
Polish (2) . .	8·28	10·84	12·81	58·43	3·28	6·36
Husks (2) . .	6·62	0·50	2·56	36·13	35·99	18·20
Japan type.						
Unhusked rice (3)	11·50	1·74	6·50	67·19	7·93	5·14
Husked rice (3) .	12·38	1·52	7·24	76·88	0·85	1·13
Skinned rice (3) .	13·38	0·31	6·59	79·03	0·29	0·40
Polished rice (3) .	12·82	0·22	6·61[1]	79·74	0·29	0·32
Meal . . .	9·39	15·13	12·81	41·8	13·54	11·33
Polish (2) . .	8·70	8·79	11·40	63·74	2·01	5·31
Husks . .	6·12	0·86	2·69	34·15	36·08	20·10

(1) Average of 4 samples. (2) Average of 2 samples.
(3) Average of 3 samples.

[1] *These analyses are unusual in showing no diminution in proteins after polishing, in spite of the fact that the "polish" taken off is richer in protein than the skinned rice from which it is removed in preparing polished rice.*

Analyses of a single complete series of products are not available in the case of Burma rice. In the following table the organic analyses of the skinned rice, polished rice, and

the by-products are taken from "The Chemical Composition of Paddy Mill Products," by F. J. Warth and D. B. Darabsett (*Bulletin* No. 10, 1913, *Dept. Agric., Burma*); they represent the averages for samples derived from three varieties of paddy. The analysis of unhusked rice is from "Indian Food Grains and Fodders: their Chemical Composition, II.," by J. W. Leather (*Agric. Ledger*, 1903, No. 7, p. 150). The analysis of husked rice is the average of five samples of Burma rice given in "The Composition of Indian Rice," by David Hooper (*Agric. Ledger*, 1908–9, No. 5, p. 535). In all cases the figures for the mineral constituents are taken from the first-named publication.

	Percentage Organic Composition						Mineral Constituents: Percentage of Total.					
	Moisture.	Proteins.	Fat.	Carbo-hydrates.	Fibre.	Ash.	Nitrogen (N).	Silica (SiO_2).	Lime (CaO).	Magnesia (MgO).	Phosphoric acid (P_2O_5).	Potash (K_2O).
Unhusked rice [1]	12·55	6·35	2·14	65·19	7·84	5·93	0·92	3·84	0·039	0·10	0·54	—
Husked rice [2]	11·68	7·71	1·19	77·79	0·70	0·93	—	—	—	—	—	—
Skinned rice	13·02	6·91	2·24	75·71	0·68	1·44	1·11	0·13	0·026	0·19	0·69	0·30
Polished rice	12·90	6·47	0·46	79·43	0·25	0·49	1·01	0·02	0·017	0·05	0·24	0·08
Meal	8·10	11·50	13·50	53·50	4·50	8·90	1·88	1·40	0·061	0·99	3·86	1·46
Polish	11·40	10·20	7·80	63·20	1·20	6·20	1·64	0·97	0·040	0·18	2·82	—
Dust	9·60	6·20	3·80	41·00	22·10	17·3	1·13	11·50	0·068	0·45	1·09	—
Husks	—	—	—	—	—	—	0·027	17·18	—	—	0·04	—

[1] *Average of 4 samples.* [2] *Average of 5 samples.*

Rice as a Foodstuff

Rice is the most important of all cereals used as human food. It forms the staple diet of most Eastern races and is also largely eaten in Europe and America. Its nutritive value depends on the form in which it is eaten, polished rice being, as a rule, poorer in all constituents, except carbohydrates, than unskinned and unpolished rice (cf. foregoing tables of analyses). There is, however, no strict relation between the chemical composition and the value of the rice from the consumer's point of view. The method of cooking also has an influence on the nutritive value of the rice. According to Hooper, in the case of Indian rice, boiling removes more than half the fat contents, over 8 per cent. of the proteins, less than 8 per cent. of the carbohydrates and 17·6 of the ash. To obtain the greatest possible value as a food rice should be steamed, not boiled; or it should be cooked by the gradual addition of water, in quantity merely sufficient to soften the rice.

The percentages of the organic constituents of rice, compared with those of other common foodstuffs, are shown in the following table:

	Water.	Proteins.	Fat.	Carbo-hydrates.	Fibre.	Ash.	Food units.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Rice, Burma, husked	11·68	7·71	1·19	77·79	0·70	0·93	102
,, ,, ,, polished	12·90	6·47	0·46	79·43	0·25	0·49	97
,, , Bihar and Orissa, husked	11·95	7·48	2·36	75·86	0·76	1·59	101
,, ,, ,, ,, ,, polished.	10·89	7·25	0·88	79·99	0·20	0·79	100
,, , Patna, coated[1]	11·97	8·06	0·18	78·59	0·46	0·74	99
,, , Siam, uncoated[1]	11·81	7·06	0·21	80·14	0·40	0·38	98
,, , Java, uncoated[1]	11·86	7·75	0·17	79·42	0·40	0·40	99
,, , Bassein, coated[1]	12·33	7·19	0·25	78·93	0·41	0·89	98
,, , Japan, partly milled[1]	11·52	6·75	1·92	77·49	1·10	1·22	99
,, ,, ,, coated	12·21	6·14	0·43	79·50	0·41	1·31	96
,, ,, ,, polished	12·82	6·61	0·22	79·74	0·29	0·32	97
,, , Chinese, uncoated[1]	12·06	6·59	0·20	80·20	0·40	0·55	97
,, , Honduras, polished	11·89	8·06	0·25	79·14	0·30	0·36	100
Wheat	13·0	12·5	1·7	68·5	2·5	1·8	104
,, , flour, straight or standard	10·54	11·99	1·61	75·36		0·5	109
Maize, dent	10·56	10·25	5·02	70·40	2·24	1·53	108
,, meal	14·98	9·17	3·77	68·76	1·90	1·42	101
Oat meal	10·0	15·0	8·0	60·0	3·0	4·0	117
Sago flour	11·70	0·13	0·13	87·56	0·13	0·35	88
Tapioca flour	12·70	0·88	0·23	80·47	4·87	0·85	83
Potatoes	74·98	2·08	0·15	21·01	0·69	1·09	26
Lentils	14·0	25·5	1·9	52·2	3·4	3·0	121

[1] *Typical of rice imported into the United States.*

It is not possible to compare accurately these different materials, as it is necessary to know the digestibility of the constituents in each case when used as human food, and this is not known in most cases. Speaking generally, rice is no more completely digested than other cereals, its proteins, indeed, being said to be slightly less digestible than those of wheat. Rice proteins, however, it is asserted, more closely resemble those of animal tissues than do those of wheat and maize.

In countries where polished rice constitutes a large part of the diet, the natives frequently suffer from the disease known as beri-beri. That the disease is caused by living mainly on polished rice seems to have been conclusively proved, as sufferers have been cured by the addition of rice polish to the diet or by the replacement of polished by unpolished rice. Funk and others maintain that the skin which is removed by polishing contains a substance or substances, known as vitamines, which are essential to normal growth, whilst others believe that the disease is caused by a deficiency in phosphates. The latter view is supported by experiments with poultry, etc., in which cases have been cured by the addition of phosphates to the diet. Although husked rice is therefore preferable to polished rice from this point of view, besides containing a greater proportion of nutritive constituents, it has the disadvantage of being more difficult to cook and, when cooked, of being

less pleasant in appearance. The question is of course only of importance where rice is practically the sole diet.

As rice is essentially a carbohydrate food, it is necessary to supplement it with foods rich in proteins, such as meat or legumes, in order to obtain a well-balanced diet. Even in China, where it is popularly supposed rice is almost the sole food amongst certain classes, and where, as a matter of fact, the annual *per capita* consumption of rice is said to amount to 300 lb., a large amount of protein is consumed in the form of preparations of soy beans, edible seaweed, etc.

Industrial Uses of Rice

In addition to its primary use as food, rice is employed in brewing, distilling, vinegar manufacture and starch-making. For the former purpose, either whole rice or broken ice is employed. In the United States the term "brewers' rice" is given to broken rice which is small enough to go through a No. 12 sieve. In the case of both whole and broken rice, the grain is usually converted into the form of grits, flakes or starch before use, but is sometimes merely crushed. The flakes are made by extracting the crude starch with tepid water so as to form a thick paste which is dried by being passed between hollow, steam-heated rollers. This form of rice is said to be capable of being saccharified at a comparatively low temperature and gives a high yield, 100 parts being equivalent to 120 to 130 parts of malt. Rice is not, as a rule, used alone in brewing, but only in admixture with malt, replacing from 20 to 50 per cent. of the latter. It tends to produce a light beer and, if a large proportion is used, the beer is said not to keep well, and the yeast deteriorates and has to be renewed or rejuvenated with malt.

As a source of alcoholic beverages, rice is used largely in Japan for the production of the drink known as saké. The special feature of the process of brewing saké is the use of a single ferment for the two operations of saccharification and fermentation. There are about 20,000 saké breweries in Japan producing 150,000,000 gallons annually. Saké is something between a wine and a beer, is of a pale sherry colour, and has a rather acid taste. There are many varieties brewed. The liquor is stored in vats made from the wood of *Cryptomeria japonica*, which gives it a characteristic flavour. There is a tax of 1*s.* a gallon on saké, which yields a revenue of about £7,000,000 a year.

In the manufacture of starch the rice is treated with a weak solution of caustic soda to soften and swell the grain. It is then washed in pure water, drained, crushed and afterwards sifted. The flour thus obtained is again treated with alkali solution and the starch is separated in a pure form by means of fine sieves, washing and settling in water. The moist starch is moulded in high-pressure

filtering moulds and then dried gradually at a moderate temperature. An acid process is often employed instead of the above. About 85 to 90 per cent. of the starch present in the grain is extracted by modern methods. Rice starch is chiefly employed for laundry work, and finely-ground rice is largely used for sizing and finishing textiles.

Rice Meal and Polish

As a general rule the rice bran or meal produced by the milling of the husked rice is mixed with the rice polish formed during the polishing process, the mixture being sold for feeding purposes as rice meal. Experiments with fattening pigs at the Arkansas Experiment Station have indicated that rice polish is of more value for feeding purposes than rice bran. A certain amount of the rice dust produced in the hulling process is also sometimes mixed with the meal. Rice meal is essentially a starchy food and is therefore much in demand for feeding pigs and for use as a diluent to nitrogenous foods, such as oil cakes, in the manufacture of compound feeding cakes. Rice polish was formerly exported from the United States to Germany, where it is said to have been used in the manufacture of buttons and similar articles.

The average composition of rice meal, compared with that of other feeding stuffs in common use, is as follows:

	Rice meal.[1]	Barley meal.[2]	Dried brewers' grains.[3]	Linseed cake.[3] English.	Palm-kernel cake.[4] English.	Maize meal.[3]	Maize germ meal.[2]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	9·72	13·29	10·1	11·16	9·4	12·45	10·45
Crude proteins	12·21	13·19	19·50	29·50	17·8	10·01	23·14
Fat	13·24	3·14	6·93	9·50	8·2	4·20	11·77
Carbohydrates, by difference	48·56	61·87	42·31	35·54	50·6	70·13	48·25
Crude fibre	7·31	5·63	17·60	9·10	10·1	1·96	5·37
Ash	8·96	2·88	3·65	5·20	3·9	1·25	1·02
Nutrient ratio	1 : 6·5	1 : 5·2	1 : 3·0	1 : 1·94	1 : 3·9	1 : 8·0	1 : 3·2
Food units	112	103	108	133	116	105	136

[1] *Average of 20 analyses quoted by various authorities.*
[2] *Journal S.E. Agricultural College, Wye,* 1912, *p.* 257.
[3] *Smetham, Journ. Roy. Lancs. Agric. Soc.,* 1914.
[4] *Analysed at the Imperial Institute.*

It will be seen that rice meal is rich in fat and carbohydrates and fairly rich in protein and compares favourably in composition with barley meal, dried brewers' grains and maize meal. The high proportion of fat is due to the fact that the meal contains practically the whole of the germ of the rice grain which is rich in that constituent. The fat however has a tendency to turn rancid quickly, and for this reason it is not advisable to store the meal for any length of time.

Rangoon rice meal is superior to the average quoted in the above table, its percentage composition, according to Smetham, being as follows:

Moisture	9·10	Crude fibre	6·23
Crude proteins	13·31	Ash	8·90
Fat	15·46		
Carbohydrates, by difference	47·00	Food units	119

Rice meal is a comparatively cheap food, as is indicated in the following table, which shows the price of various feeding stuffs at the beginning of 1917 and the cost per food unit:

	Price at beginning of 1917, per ton.			Food units.	Cost per food unit.	
	£	s.	d.		s.	d.
Rangoon rice meal	16	5	0	119	2	8¾
Barley meal	17	15	0	103	3	5¼
Dried brewers' grains	14	15	0	108	2	8¾
Maize germ meal	16	7	6	136	2	5¾
Linseed cake, English	19	10	0	133	2	11¼
Palm-kernel cake, English	15	15	0	116	2	8¾

In considering the cost of a feeding stuff, the value of the manure that results from its consumption must be taken into account. This is commonly calculated by taking the value of each unit per cent. of nitrogen in the residues resulting from the consumption of 1 ton of the feeding stuff to be 15*s.*, that of the phosphoric acid to be 3*s.* per unit, and that of the potash to be 4*s.* per unit, and assuming that half the nitrogen, and three-quarters of the phosphoric acid and potash present go into the manure when the latter is made into dung (cf. Voelcker and Hall, *Journ. Roy. Agric. Soc.*, 1913, **74**, 104). According to Warth and Darabsett (*Bulletin* No. 10, 1913, *Dept. Agric. Burma*) Rangoon meal contains 1·88 per cent. of nitrogen, 3·86 per cent. of phosphoric acid and 1·46 per cent. of potash. On this basis the compensation value of the manure per ton of feeding stuff would be 27*s.* 2*d.*, as compared with 15*s.* 8*d.* in the case of feeding barley, 29*s.* for brewers' grains, 44*s.* 4*d.* for linseed cake and 22*s.* 11*d.* for palm-kernel cake.

The price of rice meal, like that of all other feeding stuffs, has risen considerably since the outbreak of war, as is indicated in the following table which shows the highest, lowest and average prices in London or Liverpool, during the years 1913, 1914, 1915 and 1916:

	1913.			1914.			1915.			1916.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Highest	5	7	6	6 2 6 to 6 5 0			8	7	6	16	0	0
Lowest	4	5	0	3	17	6	6	10	0	6 5 0 to 7 0 0		
Average	4	14	3	4	17	6	6	2	3	9	8	4

Feeding of Rice Meal to Live-stock

Pigs.—Rice meal is much used for feeding to pigs in Holland and the present extent of the rice milling industry in that country is due largely to the fact that the by-products sell readily to the local farmers for feeding purposes. Careful feeding experiments with pigs have been carried out in this country, in Canada, the United States and elsewhere, and almost without exception rice meal has proved to be a valuable food when mixed with some other meal richer in nitrogenous substances, or with a highly nitrogenous liquid food such as separated milk or whey to form a properly balanced ration. At the South Carolina Experiment Station for example, rice meal was found to be more economical than maize meal when fed in conjunction with skimmed milk. Similar results were obtained at the Hatch Experiment Station, Massachusetts, where it was concluded that the choice between the two meals depends on relative market price. It is not advisable, however, to replace the whole of the grain ration with rice meal, as there is a tendency for pigs which are fed mainly on this food to develop weak hind legs. Experiments conducted at the Experimental Farm, Agassiz, British Columbia, seem to indicate that this injurious effect is due primarily to lack of phosphorus in the rice meal, and that this can be counteracted by the addition of ground phosphate to the grain ration.

Rice meal may be used, together with an equal proportion of maize germ meal, as a substitute for barley meal for pigs. Other substitutes for barley meal which have been recommended are (1) 2 parts rice meal, 2 parts maize meal, 1 part coconut or palm-kernel cake and 1 part bean meal, and (2) 2 parts rice meal, 2 parts maize meal and 1 part ground-nut cake.

The following rations for pigs of various ages are given in *Special Leaflet*, No. 16, *Bd. of Agric. and Fisheries*:

	Live weight of pigs.			
	40 lb.	80 lb.	140 lb.	180 lb.
Rice meal . . .	½ lb.	¾ lb.	1½ lb.	2 lb.
Middlings . . .	½ ,,	—	—	—
Sharps	—	¾ lb.	1½ lb.	2 lb.
Bran	—	¾ ,,	¾ ,,	1 ,,
Gluten meal . . .	½ lb.	¾ ,,	¾ ,,	1 ,,

Sows which are suckling young may be given 4 lb. rice meal, 4 lb. sharps and 2 lb. bran.

Milch Cows.—Rice meal is at present not used to any great extent for milch cows, except when mixed with other

foods in compound cakes, although it might well be included in the concentrated food supplied to these animals, to replace more expensive foods. A mixture of rice meal, coconut cake and ground-nut cake in equal proportions, for example, is a satisfactory substitute for the mixed linseed and cotton-seed cakes fed to cows in stalls. In conjunction with a liberal supply of green fodder cows yielding 2½ to 3 gallons of milk per day may be given 4 or 5 lb. per head per day of a mixture consisting of 1 part rice meal, 2 parts maize gluten feed and 1 part linseed cake, the amount being increased in the case of cows giving higher yields of milk.

Fattening Cattle.—Rice meal may also be employed as a diluent to cake and other concentrated foods for feeding bullocks. Feeding trials with steers at the Texas Experiment Station showed that 10 lb. of rice meal was equal to 6 lb. of cotton-seed meal when forming two-fifths of the concentrated food in the ration. For calves a suitable mixture consists of equal parts of rice meal, linseed cake, ground-nut cake and maize.

Sheep.—Rice meal is not often fed to sheep, but here again it can be profitably employed as a constituent of the concentrated food. Lambs which are fed on tares or clover aftermath may be given ¼ lb. to 1 lb. per head per day, according to their age and weight, of a mixture consisting of equal parts of rice meal, linseed cake, dried brewers' grains and crushed maize.

Trade in Rice Meal

The chief countries producing rice meal are India, Indo-China, Siam, United States and Egypt. In addition to the large quantities consumed in these countries there is a considerable export. In the case of India, rice meal is included in the official trade returns under the heading "bran and pollards." The total quantity exported under this head in 1914–15 was 194,588 tons, of which 183,697 tons were shipped from Burma, and as the Burma exports are known to consist entirely of rice meal, the figures for that country only will be considered. The United Kingdom has always been the principal customer for Burma rice meal, taking about 120,000 tons each year, the Straits Settlements and Germany coming next in importance, taking about 30,000 to 40,000 tons each in normal years. The exports from Indo-China have been taken in about equal proportions by Hong Kong, Germany and the United Kingdom, whilst Siam rice meal is sent almost entirely to the Straits Settlements and Hong Kong. The United States at one time exported about 6,000 tons of rice bran and polish each year, practically the whole of which went

to Germany, but in 1913–14 only 1,871 tons were shipped, and in 1914–15 only half this quantity; in the latter year most of the material was sent to Norway. Rice meal is not shown separately in the Egyptian trade returns, being included under the heading "son" (bran), of which about 2,800 tons were exported in 1915, mostly to the United Kingdom.

The exports of the by-products of the rice milling industry from the chief producing countries in the last year for which statistics are available are shown in the following table, together with the countries of destination:

Destination.	Burma,[1] 1914–15.	Indo-China, 1913 Rice meal and dust.	Siam, 1915–16. "White rice" meal.	Siam, 1915–16. "Cargo rice" meal.	United States, 1914–15. Rice bran and polish.	Egypt,[2] 1915.
	Tons.	*Metric tons.*	*Tons.*	*Tons.*	*Tons.*	*Metric tons.*
United Kingdom	116,798	43,111	—	—	—	1,947
Straits Settlements	35,384	361	71,484	527	—	—
Hong Kong	2,432	57,557	18,925	16,777	—	—
Other countries of the British Empire	246	—	—	—	5	2
France	—	59	—	—	1	60
French Colonies	—	678	—	—	—	—
Italy	—	—	—	—	—	654
Germany	20,091	50,416	—	—	—	—
Denmark	8,654	—	4,217	—	—	—
Greece	—	—	—	—	—	139
Norway	—	—	—	—	800	—
China	80	1	—	232	—	—
Other foreign countries	12	—	—	—	101	50
Total	183,697	152,183	94,626	17,536	907	2,852

[1] *Recorded in official trade Returns as "bran and pollards."*
[2] *Recorded in official trade Returns as "son" (= bran).*

About half the rice meal imported into the Straits Settlements is re-exported, mainly to the Federated Malay States, the Dutch East Indies and the Unfederated Malay States. The actual exports in 1915 were as follows:

Destination.	Quantity. *Tons.*
Federated Malay States	28,197
Unfederated Malay States	5,066
Dutch East Indies	9,984
Other countries	3,595
Total exports	46,842
Total imports	93,043

A large proportion of the meal imported into Hong Kong is also re-exported, but detailed figures of the trade are not published.

RICE HUSKS OR HULLS

Many attempts have been made to find a use for the enormous quantity of rice husks which accumulate during the milling process. In Burma a large proportion of the husks is simply thrown into the rivers, a practice which tends to silt up the rivers. Some of the husks are used as fuel in the rice-mills, and attempts have been made to convert them into briquettes in conjunction with petroleum by-products; the calorific value of the husks is sufficiently high to admit of their use for the latter purpose, but difficulty has been experienced in preparing a sufficiently coherent briquette, owing to their resilient nature. They are also employed as a packing material, and it has been suggested that they might be utilised in the manufacture of linoleum. Trials which were carried out by a firm of manufacturers, in conjunction with the Imperial Institute, did not, however, give promising results for the latter purpose.

Rice husks have been used as a "filler" in compound feeding stuffs for livestock. They are of comparatively little nutritive value, as is clear from the following statement of their composition, and, owing to their hard, siliceous nature, are actually dangerous to stock. The husks are occasionally ground and used as an adulterant of barley meal, sharps and middlings, but their use for this purpose, unless their presence is definitely stated, renders the seller of such feeding stuffs liable to a penalty under the British Fertilizers and Feeding Stuff Act.

The composition of rice husks is as follows; the figures given represent the average of seven analyses quoted by various observers.

	Per cent.
Moisture	9·02
Crude proteins	3·27
Fat	1·18
Carbohydrates (by difference)	33·71
Crude fibre	35·68
Ash	17·14

NOTES

Pistachio Nuts and their Cultivation.—The pistachio tree, *Pistacia vera*, Linn. (Nat. Ord. Anacardiaceæ), has long been held in high esteem in the countries in which it is grown on account of the delicate flavour of its seed-kernels. Native to Syria and Persia, the tree is more or less cultivated in the whole of the sub-tropical Mediterranean region of Europe and Africa as well as in the Caucasus and in several parts of Western Asia.

The seed-kernels ("pistachios" or "pistachio nuts") have become a fairly important article of commerce. The extent of the trade is illustrated by the French returns, which to a large extent represent re-export trade; the imports into France, mainly from Russia and Turkey, in 1913 were 4,280 cwts., valued at £52,200, and the exports were 3,517 cwts., valued at £42,888; of these exports 1,982 cwts. went to the United States and 478 cwts. to the United Kingdom. Italy in the same year exported pistachios to the value of £20,600 and imported them to the value of £1,040, probably chiefly from Syria and Cyprus.

The uses of the pistachio nut are similar to those of the almond; they are eaten as a dessert nut and used in a variety of ways in confectionery and for culinary purposes. The kernels yield on pressure a greenish, sweet-flavoured oil which is not often prepared.

The composition of the kernels is as follows:

	Per cent.		Per cent.
Water	7·4	Cellulose	2·5
Crude proteins	22·7	Ash	3·3
Fat	51·1		
Carbohydrates, etc. (by difference)	13·0	Nutrient ratio [1]	1 : 5·75
		Food units [2]	197·5

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The oil has the following constants:

Specific gravity at $\frac{15^\circ \text{C.}}{15^\circ \text{C.}}$		0·9185
Saponification value		191·0–191·6
Iodine value	*per cent.*	86·8–87·8
Solidifying point of fatty acids		13°–14° C.

The pistachio is a small, spreading tree, varying in height from about 20 to 35 ft. The male and female flowers, which are borne on separate trees, grow in clusters, and appear in March and April, the male flowers developing rather before the female ones.

The fruit, which ripens in August and September, is a drupe, varying somewhat in size according to the amount of cultivation which the tree has received, but generally not more than about an inch in length. It is more or less elliptical in shape and of greenish-yellow colour, turning red where it is exposed to the direct rays of the sun. The kernel is bright green and covered with a reddish-purple pellicle. The fruits are picked at maturity, when they are of a deep yellow colour, and are dried by being spread out in the shade. The kernels, before being exported, are almost always removed from the fruits. The yield of

kernels is variously stated at from 25 to 60 lb. and upwards per tree per annum.

The climatic requirements of the pistachio are generally stated to be much the same as those of the olive. In its original habitat the pistachio tree is stated to occur at altitudes of 3,000 ft. and upwards, and generally on sandstone formations; it prefers a light soil, but will grow on almost any soil that is not too damp. It is resistant to wind, and can withstand a few degrees of frost in winter; but it requires a high summer temperature in order to fruit plentifully. It is commonly reputed to yield a good harvest only in alternate years.

It appears to produce fruit to greatest perfection in Sicily and Tunis, but in the latter country its cultivation is not now carried on to so great an extent as formerly, and in Sicily it has never been exploited so largely as might have been expected from the readiness with which it grows in that island.

The tree can be propagated either by sowing, budding, grafting or layering, budding being most commonly practised. It can readily be budded or grafted on other species of *Pistacia*, and by this means hardier trees are obtained which will flourish under climatic conditions otherwise unfavourable; thus it will bear fruit in Central France when the terebinth, *P. Terebinthus*, Linn., is used as the stock, for which purpose the latter is commonly grown from seed. In order to ensure successful propagation two or three buds are inserted on the same stock.

After budding or grafting, the tree may begin bearing fruit in two or three years; when it is grown from seed, however, it does not fruit till it is at least six or eight years old, and another disadvantage of raising it from seed is that it is necessary to wait until the flowers appear before the male trees can be distinguished from the female. As a rule about one seed in ten produces a male tree.

Propagation can also be effected by means of cuttings, but the trees obtained in this way are stated to be short-lived.

Once the pistachio is well established it requires but little attention; pruning, irrigation or other treatment is not generally necessary. The tree can be transplanted readily.

An important point with reference to its productivity is the fact already mentioned that it is diœcious. This fact has not always been properly appreciated, and in the East the trees producing male flowers appear commonly to have been merely regarded as barren.

In order that the tree may fruit well it is necessary that there should be a fair proportion of male trees present; one to every four or six female trees is recommended, though if the trees are in fairly close proximity it is

probable that a smaller proportion of male trees will be sufficient. In any case the distance from any female tree to the nearest male tree should not be more than about 20 yards. The same end can, however, be attained by causing one or two grafts from a male tree to grow on a female tree, or to insert buds from both kinds of trees on the same stock. In Sicily, when the male and female trees grow too far apart, artificial means are employed for securing fertilisation; thus flowers from a male tree are placed in flower pots in damp earth close to the female tree, or a branch bearing male flowers is placed over the female tree. A former Sicilian practice, according to Parlatore (*Flora Italiana*, vol. v., p. 375), was to collect the pollen in small bags and scatter it over the female flowers as soon as they opened, or sometimes the whole male flowers were collected and dried, and then applied to the female flowers.

It is probable that the cultivation of the pistachio could be considerably extended. In Cyprus it grows readily, being commonly budded or grafted on *P. Terebinthus*, Linn., and *P. Lentiscus*, Linn., both of which occur there naturally; but it does not bear fruit readily on account of the scarcity of male trees, of which it is said that there are only a few in the whole island. It seems reasonable to suppose that its cultivation in Cyprus could be considerably developed by increasing the number of male trees by budding them on terebinth stocks.

In India, too, its cultivation could probably be extended; at present the kernels are largely imported into that country, chiefly from Afghanistan, but the tree is only cultivated in the north-west and in small numbers. It also appears possible that its cultivation might be successful in the southern hemisphere, for instance in Australia and in South Africa.

Palm-Nut-cracking Machinery.—In the last number of this BULLETIN (1917, **15**, 57) an account was given of the machinery which is used, or has been devised for use, in the West African palm-oil industry. In the following paragraphs two further machines designed for cracking palm nuts and similar materials are dealt with.

An ingenious and simple nut-cracking machine has been devised recently by J. O. Drews. It consists essentially of a pair of finely corrugated steel jaws, one of which is fixed vertically to the frame of the machine while the other is moved by means of a specially constructed cam. The moving jaw has its corrugated face formed at a slight angle to the face of the fixed jaw; the space between the jaws is therefore wider at the top than at the bottom, so that larger nuts dropped between the jaws lodge near the top and small nuts near the bottom. In working, the moving

jaw takes up three consecutive positions: (1) discharging, fully open, allowing the broken nuts to fall through; (2) feeding, partly closed; (3) cracking, a small auxiliary cam mounted on the main cam engages with the operating rod of the moving jaw, causing the latter to take a short sharp movement and to crack the nut-shells without breaking up the kernels. The nuts are fed to the jaws by means of a sloping tray ending in a series of ⌋-shaped bars mounted at right angles to and above the faces of the jaws. A series of ⌋-shaped bars mounted on a shaft rotate between the bars on the feed tray, pick up a row of nuts, and throw them between the jaws. The machine is light, simple and strong, and appears to work well; but trials on a large scale are necessary to determine how this machine will compare in actual use with other machines.

The working of a new palm-nut-cracking machine devised by Mr. Kent Johnston has been demonstrated recently in Liverpool (*West Africa*, 1917, **1**, 107). The machine works on the centrifugal plan, but differs from other centrifugal machines in that the nuts are flung from one ribbed rotating disc or drum into or against another disc rotating in the opposite direction. The machine is said to work satisfactorily, and weighs 130 lb., being of convenient size for transport.

The Whaling Industry.—The following information, which supplements that given in an article published a few years ago in this BULLETIN (1914, **12**, 262), is taken from a paper by W. Mansbridge which appeared recently in the *Journ. Soc. Chem. Indust.* (1917, **36**, 362).

In 1894 whalers commenced to visit the Faroe islands, and since then six whaling stations have been established there with 13 to 17 ships. Fishing in Scotch and Irish waters has not been productive, but the one or two companies still do well here. At the commencement of the century the Norwegian whalers extended their operations to Newfoundland, Ireland and Spitzbergen with success, and in 1904–5 it was found that whales existed in abundance in the South Pacific and Atlantic oceans; whaling stations were established at this time in South Georgia, the South Shetland Islands, the Falkland Islands, and Kerguelen, and most of the world's supply of whale oil is now drawn from these sources. The great distances covered by the whalers have necessitated changes in the methods of working and a return to the old practice of "trying out" the blubber on board ship. The "floating factories" now used often consist of an old liner fitted with tanks below deck and with trying plant on the upper deck amidships. Towards the end of the summer, building materials, machinery, barrels, provisions, coal, and other stores are taken to the land station and the vessel then

sails for the fishing grounds in company with several small steamers, generally of about 120 tons, which are used for the actual capture of the whales. The oil is obtained from the blubber by steaming for about 7 hours in large iron cooking tanks capable of withstanding 100 lb. pressure and fitted with large manholes for charging and discharging. After cooking, the oil is run off, separated from water, and stored in tanks or barrels. The quality of the oil depends largely on the skill exercised in cooking; if undercooked, a pale oil is obtained which turns rancid during storage, which often lasts for several months, while overcooked oil is dark in colour. Although oil of pale colour is desirable, extra pale oil does not now obtain a premium and it is considered better to turn out a well-cooked oil of No. 1 grade rather than to sacrifice other qualities to obtain pale-coloured oil. Cold pressing of the blubber has been tried without success and has now been abandoned. Fears have been expressed frequently that the modern methods of capturing whales will cause a decline in the industry owing to the rapid killing off of the whales and the author has made attempts to discover the time taken for whales to reach maturity. It appears that their growth is very rapid, and in the case of the humpback whale (*Megaptera longimanus*) it is stated that full growth is reached in about two years. If this is correct, it should be a long time before a shortage will occur even under present conditions.

In 1911 the Norwegian catch in the Southern fishery was 12,635 whales, yielding 306,000 barrels of oil or nearly 25 barrels per whale; the world's production of oil in 1911 amounted to 485,000 barrels, and in 1916 it had risen to 634,500 barrels. The extent of the industry is shown by the fact that there were in 1912, 54 floating factories, 6 cargo ships, and 267 fishing vessels engaged in whaling; some of the floating factories are now being used for carrying other oils, so that a temporary falling off of the supply of whale oil is likely.

In 1916, 351,000 barrels of whale oil were imported into the United Kingdom, of which two-thirds came to Liverpool. This port possesses special facilities for unloading and distributing the oil, while its position in a large industrial area and near several large soapworks is particularly advantageous.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally.*

AGRICULTURE

FOODSTUFFS AND FODDERS

Fodder Plants.—An account of various wild Indian grasses and leguminous plants which serve as food for cattle has been published as *Bulletin* No. 78, 1916, *Dept. Agric., Bombay*, under the title of "Some Wild Fodder Plants of the Bombay Presidency." Information is given with regard to the habitat of these plants, their life-history, chemical composition, feeding value and their vernacular names. The work is provided with plates of the thirty-four plants described, and it will doubtless be of great assistance in enabling farmers to determine whether the vegetation of any particular land is suitable for cattle and to ascertain by inspection the value of loads of fodder brought in from the jungle.

Limes.—In the *Rep. Agric. Dept., Dominica*, 1915–16, an account is given of the progress of the lime industry. Although the climatic conditions during 1915 were unfavourable, the output of lime products was satisfactory, the crop, calculated in barrels of fruit, amounting to 390,000 barrels as compared with 388,000 barrels in 1914. About 59 per cent. of the crop was used for the production of concentrated juice, 26·5 per cent. for raw juice, and 3·5 per cent. for citrate of lime, whilst the remaining 10·5 per cent. was disposed of as fresh limes. Whilst concentrated juice and fresh limes maintained practically the same position as in 1914, the percentage of raw juice was more than doubled, and the export of citrate of lime fell from 18 to 3·5 per cent. The reduction in the last-mentioned product was due partly to the increased demand for raw juice for the use of the British Navy and for the armies of the allied nations, and partly to the preference at present given to the production of high-grade concentrated juice by means of steam-heated evaporators. Attention is drawn to the fact that, in spite of the importation of artificial manures to the value of £5,337, the amount available was far from meeting the requirements of lime cultivation. It is pointed out that it is economically unsound to import artificial manures, and that it would be more profitable to increase the local pro-

to deal with the entire output of under-sized nuts of the Atlantic coast of Nicaragua.

The Report of the Commission appointed in 1916 to investigate the coconut-beetle pest (*Oryctes nasicornis*) in Samoa (*Rep. Commission of Enquiry concerning the Coconut Beetle in Samoa, Malua*, 1916) contains much information gathered from the forty witnesses examined by the Commission, and as a result of inspection of a number of plantations and groves. The pest has been known in Samoa for about six years, and it appears that, although the area affected has increased in recent years, it is not proved that the actual damage inflicted has been on the increase. Trees in many districts which were badly affected have recovered, and some which seemed dead are bearing fruit again. Many trees which were attacked have been cut down, and on two neighbouring plantations 13,000 trees were thus destroyed; as a result the beetles have been driven further afield in search of food, and it would probably have been wiser to leave some trees to act as traps, as the beetle does not go far afield if food exists near its breeding-place.

The pest is well established in the Faasaleleaga and Palauli districts of Savaii, but in the three years during which the beetle has been known there, large areas have been cleared and planted, and there seems to be no need for alarm if adequate care is taken to control the pest. Records of the largest European plantations show a steady, but small increase in the yearly production of nuts since the pest first occurred until the year of report, in which there was a serious falling off. This falling off is attributed by some witnesses entirely to the attacks of the beetle, but this view is not accepted by the Commission, who attribute it to the effect of storms and drought. On the coast the pest is being held in check, but is very bad in certain inland plantations.

In dealing with the pest the first essential is that plantations should be kept in clean condition; banana patches, rubbish heaps, rotten wood, or the husks of cocoa pods all form ideal breeding-grounds for the beetle. Cattle are of use in keeping plantations clean, and as there are many areas suitable for cattle raising in Samoa, cattle should prove valuable; the cost of establishing cattle and erecting the necessary fencing is, however, too great for immediate needs. Pigs are also very useful as destroyers of larvæ.

The method advocated by Dr. Friedrichs (this BULLETIN, 1914, **12**, 305), in which heaps of decayed wood and husks of cocoa pods are infected with a fungus injurious to the larvæ, appears to be slow in action and expensive to apply as it needs skilled supervision, while the traps are liable to be dangerous in affording good breeding-grounds unless carefully watched. There is abundant evidence of the existence of the beetle in virgin bush, as well as of its

preference for wild palms, and there is, therefore, little hope of totally eradicating the pest. Protective belts of wild palms might be of use, but it is considered that the production of "toddy" from them would be injurious to the natives.

Thorough searching of trees for the pests is essential, but the climbing of trees by natives and searching of tops is deprecated on the ground of frequent damage to the trees. It is recommended that all natives, except those in the Government employ, should be compelled to spend one day a week in searching for and destroying the pest, and that more white inspectors should be appointed.

The areas owned by natives are often so large that the owners cannot control them properly, and assistance will be necessary in such cases. An unfortunate result of offering prizes for the collection of beetles and larvæ has been the breeding of beetles and larvæ by natives, a practice that has also been recorded under similar conditions in other countries, and in Java payment has been discontinued.

Proposals that attempts should be made to find a natural enemy of the beetle were not considered feasible, as the pest has been known in other countries for many years, and no natural enemies have been discovered.

Among the addenda to the report is a report on the remedial measures adopted in Ceylon, and a statement by the Ceylon Government Mycologist that Dr. Friedrichs's fungus was tried in Ceylon without success.

Ground Nuts.—The wilting of ground nuts grown on the Virginia truck experiment station in 1915 has been found by McClintock (*Journ. Agric. Res.*, 1917, 8, 441) to be caused by a fungus (*Sclerotium Rolfsii*), which had been recorded previously by Wolf as the cause of fruit-rot of ground nuts. The fungus appears to have been introduced to the plots with Valencia seed. The disease became apparent under field conditions when the plants were one to two months old, and caused destruction of the tissues of shoots near the surface of the soil, white mycelium with brownish sclerotia being apparent on the stem-bases, on leaves dropped by the wilted plants and also in and on the pods. No fruit was produced by plants attacked early in the season, and those attacked later generally failed to mature their fruit.

Selection of healthy seed did not appear to reduce the disease on the plots, and rotation experiments over three years showed that the fungus lived in the soil for that period. Experiments with different varieties showed that Valencia nuts were most susceptible, and that Spanish, Tennessee red, and Virginia bunch were resistant in the order named, while the Virginia running and African varieties and also *Voandzeia subterranea* were practically immune.

Olives.—The possibility of the extension of olive cultivation in South Australia has been discussed recently by Perkins in the *Journ. Agric., South Australia* (1917, **20**, 443). The author considers that the olive is well adapted to the conditions existing in the central and northern parts of Eyre's Peninsula, the mallee lands of Buccleugh, Chandos and the Murray River, and in any of the cultivated mallee districts where the rainfall is light and the soil contains sufficient lime. The general cultivation of olives by farmers in groves or belts to form shelter for stock is recommended rather than the establishment of large individual olive plantations. Experiments on these lines are being made at the Eyre's Peninsula Experimental Farm at Minnipa. In order to encourage olive cultivation it is recommended that: (1) State oil factories should be established in districts growing olives on an appreciable scale, the factories to pay full market rates for the olives; (2) special railway facilities should be granted where plantations are distant from factories; (3) Government should offer a yearly bonus of 10*s*. to 20*s*. per acre until trees are ten years old. It is suggested that in all future allotments of land suitable for olives the Government should reserve the right to resume on one year's notice a belt of land 400 ft. wide from boundaries to be planted with ten rows of olive trees; the necessary fencing and planting of these would supply work for returned soldiers, and the crops of olives should enable farmers to tide over temporary losses owing to failure of cereal crops.

Statistics show that the annual production of olive oil in South Australia has been very irregular since 1905, rising in 1913 to nearly 27,000 gallons and falling to less than 2,000 gallons in 1914; the average during this period was nearly 15,000 gallons. The demand for edible oils in the Commonwealth is fairly large, and oils such as cotton-seed oil pay an import duty of 2*s*. 6*d*. per gallon. The price of olive oil is much higher than in Europe, being 11*s*. per gallon before the war and 13*s*. in 1917. It is estimated that an increase in the area under olives to 15,000 or 20,000 acres in the next ten years would not cause any local surplus. The cost of production is estimated at about £11 per acre, the most expensive item being picking, which costs £4 to £5 10*s*. per ton.; as 1 acre should produce 2 tons of olives selling at the factory at £11 per ton, the net profit should amount to about £9 to £10.

Miscellaneous.—The seeds of *Hyptis spicigera*, Lam. (Nat. Ord. Labiatæ), a plant which grows wild and is also cultivated in several parts of West Africa, are stated by Jumelle to yield about 21 per cent. of drying oil suitable for use in paints and varnish. The yield of oil is practically the same as that obtained at the Colonial Institute, Amsterdam (cf. this BULLETIN, 1916, **14**, 126), and is less than that recorded

previously (37 per cent.) by Milliau; it seems doubtful, therefore, if the seed is likely to prove of commercial importance (*Les Matières Grasses*, 1917, **10**, 4681).

The small oil mill erected at Salisbury, Rhodesia, in 1915, has proved very successful, and extension of the factory and plant is recommended, as the present plant is incapable of dealing with more than a small fraction even of the ground-nut crop (*Interim Rep. Rhodesian Munitions and Resources Committee*, 1916, p. 14). The oil produced is of good quality, but the local demand is small and export is not possible under present conditions; soap is therefore manufactured from the oil and meets with a ready sale, as does the oil-cake.

The results of an interesting series of experiments on the digestibility of several vegetable oils commonly used for human food are given by Langworthy and Holmes (*Bulletin* No. 505, 1917, *U.S. Dept. Agric.*). The experiments were carried out on similar lines to those made previously with animal fats, and comprised feeding experiments on men with olive, cotton-seed, ground-nut, coconut and sesame oils. No appreciable difference in the digestibility of the different oils was apparent, and the experiment showed that these vegetable oils may, like animal fats, be used satisfactorily for human consumption. Experiments were also conducted with cocoa butter, which was found to be less digestible than the above-mentioned oils, and when eaten in fair quantities (3–4 oz. per day) to cause unpleasant physiological derangement.

In a recent article (*Journ. Soc. Chem. Indust.*, 1917, **36**, 192) Challinor and Penfold have dealt with the use of the Australian dugong or sea-cow as a source of oil. The dugongs are killed in Queensland chiefly for the sake of the oil, but the flesh is eaten, and use is also made of the hide, bones and tusks. The oil appears to be employed chiefly for medicinal purposes, but is quite free from nauseous taste, and is said to be suitable for culinary purposes. About 600 gallons are produced annually. The authors have submitted the oil to chemical examination, and the results are of interest as representing authentic material free from adulteration with other oil; some preliminary work on the composition of the oil has been carried out, and further work is being done.

Chapman has discovered (*Journ. Chem. Soc.*, 1917, **111**, 56) nearly 90 per cent. of an unsaponifiable hydrocarbon, which he has named spinacene, in the liver-oils of two species of fish, viz. *Centrophorus granulosus* and *Scymnus lichia*, which occur in the Mediterranean off the Moroccan coast. This discovery of the natural occurrence of a hydrocarbon in fish-liver oil is of interest, as hitherto it has been assumed that the presence of such a compound in fish oils is due to adulteration with mineral oil. The occurrence in Japanese

shark oils of a similar, and possibly identical hydrocarbon has been recorded by Tsujimoto.

RUBBER

Hevea.—Trees at the experimental stations in British Guiana have made satisfactory progress with the exception of those at Georgetown, where the trees have only grown to about half the size of others of the same age at other stations (*Journ. Bd. Agric., Brit. Guiana*, 1916-17, **10**, 81). The tapping of trees and preparation of rubber have been continued with good results; at Issorora, 428 trees, 5-7 years old, yielded in one year 854 lb. of biscuit rubber and 146 lb. of scrap, etc., or over 2¼ lb. per tree per year.

In one experiment 300 trees, tapped by one man and a boy at a cost of 3½*d.* per lb., yielded 873 lb. of rubber; the rubber sold in London in February 1916 at 3*s.* 4½*d.* per lb. for biscuits and 2*s.* 10*d.* per lb. for scrap. Except at the Onderneeming station trees were attacked by a leaf disease which causes recurrent defoliation, and which is found to be due to *Fusicladium macrosporum*, Kuyper. The disease is probably identical with the leaf disease occurring on Hevea trees in Dutch Guiana and in Brazil (*loc. cit.*, p. 13). It was first noticed in 1909, increased greatly in 1914, and is now present in most parts of the colony, but is not prevalent on trees on or near the coast.

The disease has been investigated in Dutch Guiana, and in a preliminary report by Dr. Stahel, the Government Mycologist (*Ind. Rub. World*, 1917, **55**, 297), it is suggested that all young leaves, which are chiefly attacked by the fungus, should be cut away during three or four weeks of the dry season when the latex is not sufficiently plentiful for tapping. Spraying with Bordeaux mixture is not regarded as suitable, as young leaves are killed by the treatment, though it appears to be effective on leaves two to four days old.

Arrangements have been made to carry out experiments in the control of the abnormal leaf-fall (cf. this BULLETIN, 1916, **14**, 128) of Hevea trees in Southern India (*Planters' Chron.*, 1916, **11**, 629; 1917, **12**, 54).

The following experiments will be made on areas of about 100 acres on a number of estates:

(1) Cut out all large and small branches which have died back; (2) remove all last year's fruits and fruit-stalks; (3) collect from the ground and destroy, by burning or burying, all leaves, fruits, and branches; (4) remove all fruits by June 1 or, at latest, by June 10; or (4a) remove the flowers and later on remove any stray fruits. The efficacy of these measures will be estimated by comparing the leaf-fall on the treated areas with that on similar untreated areas, and by comparison with past results. It

is hoped that an effective means of control will be discovered, as much loss is now caused by leaf-fall.

Attention has been drawn already (*Bulletin* No. 14, 1916, *Dept. Agric., Burma*, cf. this BULLETIN, 1916, **14**, 476) to the occurrence of "black thread" disease (*Phytophthora* sp.) in Burma. The subject has now been dealt with more fully by Dastur (*Memoirs Dept. Agric., India, Botanical Series*, 1916, **8**, 217), who describes the microscopical characters of the fungus, and compares it with other similar fungoid pests. The disease is stated to be similar to the "bark-rot" of Hevea in South India (*Planters' Chron.*, 1916, **11**, 382), an effective remedy for which is said to be the stoppage of tapping and application of a thin smear of a mixture of tallow and tar to the diseased portion of the tree.

According to Stevens (*Journ. Soc. Chem. Indust.*, 1917, **36**, 365), the cause of the rapidity of cure of rubber prepared by allowing the coagulum to remain in a moist condition for a considerable period before rolling and drying, is the presence in such rubber of basic nitrogenous substances derived from the protein by putrefaction. Similar substances were extracted from the liquor remaining after removal of the coagulum. Very small quantities of these basic nitrogenous substances are stated to exert a marked effect on the rate of cure.

Coagulation by means of sugar has been tried at times when acetic acid was expensive, and rubber prepared in this way has been found (*Mededeelingen* No. 2, 1917, *Centraal Rubberstation, Buitenzorg*, pp. 1 and 10) not to differ appreciably from that prepared by means of acetic acid.

The results of experiments on the influence of the rolling (crêping) of freshly-coagulated rubber (*loc. cit.*, pp. 13 and 19) on the quality of the vulcanised rubber are similar to those obtained at the Imperial Institute (this BULLETIN, 1916, **14**, 532) and show that excessive rolling has but little effect. Experiments on the effect of dilution of latex before coagulation (*Med.* No. 2, 1917, *Cent. Rubberstation, Buitenzorg*, pp. 21, 29) showed that dilution generally had no effect on the tensile strength of the vulcanised rubber, though in some cases dilute latex gave a lower tensile strength; the time of cure was found to be increased by dilution. Increase in the amount of acetic acid above the minimum amount required for coagulation was found to have no effect on the tensile strength of the vulcanised rubber, and little or no effect on the time of cure (*loc. cit.*, pp. 31 and 36, cf. this BULLETIN, 1916, **14**, 501).

Some of the work of Ostromyslenski on the vulcanisation of rubber by substances other than sulphur has been repeated by Stevens (*Journ. Soc. Chem. Indust.*, 1917, **36**, 107), who has failed to obtain vulcanisation by nitrobenzene; di- and tri-nitrobenzene and benzoyl peroxide were found

to cause vulcanisation, though the physical properties of the rubber produced were in all cases much inferior to those of rubber vulcanised with sulphur.

Gutta-percha.—In the course of a short general article on gutta-percha (*Agric. Bulletin, F.M.S.*, 1916, 5, 25), Barnard describes the different trees yielding gutta-percha, and discusses their distribution (more particularly in the Federated Malay States), the methods of extraction, the yield obtainable, and a number of other points of interest. Gutta-percha is derived from several different trees, the commonest species in the Federated Malay States being *Palaquium oblongifolium* known as "Taban merah," and *P. obovatum* or "Taban puteh." The latter species yields a resinous gutta of inferior quality. *P. oblongifolium* is confined to land below 600 ft. elevation, while *P. obovatum* is usually found at a slightly higher elevation; neither species occurs on land which is not well drained. Gutta is generally obtained from the trees by felling them and cutting rings round the stem with a gouge, when the gutta coagulates to a large extent in the cuts and some is also collected in cups. Reliable figures of the yield obtainable are lacking, but the method is obviously wasteful and had led to destruction of all but the young trees in the more accessible parts of the country before the practice was prohibited by law, while it is impossible to enforce the regulations in remote districts. Tapping experiments made during recent years have given encouraging results and have shown that gutta can be produced at a profit by this means. Up to the present there is no general indication of a decrease in yield, but it is not yet certain what effect continued tapping will have on the trees. Gutta is also obtainable from the leaves of *P. oblongifolium* and *P. borneense*. The leaves contain about 5 per cent. of gutta and, allowing for a loss of 20 per cent. in extraction, it has been estimated that the Government plantation at Tjepetir in Java should produce 40 lb. per acre per year when in full bearing. The method of extraction consists in cutting up the leaves and crushing and washing them between rollers. The gutta prepared in this way from leaves is inferior to that obtained from the stem owing to the presence of colouring matter. There are two factories for the extraction of gutta from leaves, one in Java and the other in Singapore.

The cultivation of gutta trees is not easy owing to the fact that seed is not obtainable in large quantity and loses its germinating power rapidly, while propagation by cuttings or other means is also difficult. The only existing plantation on a large scale is that at Tjepetir in Java, where there are 3,000 acres of *P. oblongifolium* and *P. borneense* grown chiefly for the purpose of extraction of gutta from the leaves. An experimental plantation of about 40 acres

of *P. oblongifolium* at Trolak in Perak has not given encouraging results so far owing to "lalang" grass.

In the Federated Malay States, where there are large natural supplies of trees in the forests, it is not intended to extend plantations. Improvement of the forests has been carried out for some time past, 13,843 acres being treated up to the end of 1915; the method of treatment consists in the removal of creepers and other growths detrimental to gutta trees and leads to the formation of almost pure forest of gutta trees.

Gutta trees are subject to the attacks of the caterpillars of *Rhodoneura myrtoea*, Drury, and of *Ophiusa serva*, Fabre, and these may cause loss where the leaves are being used as a source of gutta; a leaf gall insect of the order *Psillidae* is also found on mature trees, but does not appear to cause any damage. Owing to difficulties of cultivation and the long period before trees come into bearing, development by private companies is unlikely; the author considers it advisable therefore that the Government should take steps to improve all the best natural forests in the Federated Malay States.

Fibres

Jute.—Some interesting results obtained in connection with jute growing are recorded in the *Ann. Rep. of the Fibre Expert, Dept. Agric., Bengal*, 1915–16. A study of the effect of manures on the yield of jute on acid red soils has been carried out at the Dacca Farm and has shown that by the application of slaked lime and phosphates an average yield per acre of 15½ maunds (1,240 lb.) was obtained as compared with 9¼ maunds (740 lb.) from similar land which had not been so treated. A corresponding increase was obtained by the application of lime and bone on several plots of cultivators' land near the Dacca Farm. These results were so convincing that over forty cultivators in the neighbourhood of the plots have purchased lime and bone for manuring their jute land.

An investigation of the effect of wood ashes as a manure for jute has shown that the application of potash causes a further increase in the yield beyond that due to the action of lime. The plants which had received potash had thicker stems, a deeper green colour and a generally healthier appearance. It is suggested that the water hyacinth (*Eichornia crassipes*) and another water-weed, known as "pana gach" (*Pistia stratioides*), might be used as a source of potash. The former grows rapidly in the waterways in the neighbourhood of Naraiganj and endangers the blocking of important channels. In the fresh state, this plant yields 1 per cent. of ash, containing one-fifth of its weight of potash.

Work has been continued at Dacca on the selection of

jute and the distribution of improved seed, and several new races which have shown promise either as giving large yields or making rapid growth are being carefully investigated. As a larger yield of seed is produced in a dry climate than in a wet one, it has been decided that, for the production of seed on a large scale for distribution, arrangements shall be made with planters and others in Bihar instead of establishing seed-farms in the damper climate of Bengal. It is estimated that if the departmental seed were grown throughout the whole of the jute tracts, the average yield would be increased by about 1½ maunds (about 120 lb.) per acre per annum; a further increase of like amount could be achieved by applying other known improvements. It is calculated that the value of the annual output could thus be increased by about £6,000,000, by improved agricultural practice.

Sisal Hemp.—In this BULLETIN (1915, **13**, 445) reference has been made to various suggestions for utilising the refuse obtained in the course of extracting Sisal hemp. In Yucatan it has been found possible to ferment the leaf-waste for the production of alcohol, and it is stated that most of the alcohol thus obtained is produced from leaves containing, on the average, 12 per cent. of sugar.

Experiments which have been carried out in the East Africa Protectorate (*Ann. Rep., Dept. Agric., B.E.A.*, 1914–15) have shown that the juice of the leaves, whether grown at the Coast or in the Highlands, does not contain more than 3 per cent. of sugar. A yeast has been isolated from Sisal plants which is capable of fermenting a glucose solution, but is rapidly killed in the Sisal extract, probably on account of the large quantities of organic acids present. On neutralising the Sisal extract with sodium carbonate and adding a little glucose, it was found possible for the yeast to live but no fermentation was induced.

Paper-making Materials.—It is stated in the *Board of Trade Journ.* (1917, **96**, 785) that a firm in Cape Town has been granted the exclusive right to manufacture pulp for paper from the baobab tree (*Adansonia digitata*) in Mozambique on condition that works are started within two years from the date of the concession.

Cotton

Egypt.—In the *Agric. Journ., Egypt* (1917, **6**, 15), a table is given showing the percentage of the total cotton area occupied by each of the different varieties grown during the years 1911–12 to 1914–15. It is interesting to observe that the area planted with Mitafifi cotton has diminished from 40·2 per cent. in 1911–12 to 17·7 per cent. in 1914–15, and that planted with Yannovitch from 13·9 to 2·4 per cent. On the other hand, the area devoted to Sakellaridis has

increased during the same period from 11·5 to 46·2 per cent., this remarkable expansion being due to the special demand which has arisen for this cotton and the comparatively high prices realised by it. The percentage areas occupied by the different varieties in 1914–15 were as follows: Mitafifi, 17·7; Assili, 4·2; Yannovitch, 2·4; Nubari, 9·0; Sakellaridis, 46·2; Abassi, 0·6; Voltos, 0·4; Ashmouni, 19·5.

An account of the work carried out at the Cotton Demonstration Farms in Egypt in 1915 has been given by Mr. Gerald C. Dudgeon, Consulting Agriculturist, Ministry of Agriculture, in the *Agric. Journ., Egypt* (1917, **6**, 42). The results of the work have established the important fact that if the cotton is planted early and carefully treated the entire crop can be harvested before the pink boll-worm (*Gelechia gossypiella*) has been able to cause much severe damage. In most cases, in both Lower and Upper Egypt, the whole of the cotton produced at the Demonstration Farms was gathered between the last week in September and the middle of October.

West Indies.—An account of the cotton industry of the St. Kitts-Nevis Presidency is given in the *Rep. Agric. Dept., St. Kitts-Nevis*, 1915-16. The area devoted to the crop amounted to only 2,300 acres as compared with 5,500 acres in 1914-15, this large reduction being due to disturbed market conditions and the high prices obtainable for sugar. The area planted in each island was as follows: St. Kitts, 900 acres; Nevis, 900 acres; Anguilla, about 500 acres. The cotton season of 1915 was very unfavourable in St. Kitts, especially in the northern districts where the rainfall was abnormal, and, as a rule, the yields were unsatisfactory, the average being only about 90 to 100 lb. per acre. The cotton was of good quality, however, and realised prices of 1*s*. 7*d*. and 1*s*. 8*d*. per lb. In Nevis, also, the weather was unfavourable, and much damage was done to the crop by a violent storm, in consequence of which a yield of only 60 lb. per acre was obtained. The exports of cotton from each island for the year ending September 30, 1915, were as follows: St. Kitts, 397,567 lb.; Nevis, 305,154 lb.; Anguilla, 33,750 lb., making a total of 736,471 lb. as compared with 735,547 lb. in 1913-14, and 653,209 lb. in 1912-13.

FORESTRY AND FOREST PRODUCTS.

Eucalypts in the Federated Malay States.—An account of cultivation experiments with various species of Eucalyptus at Kuala Lumpur, in the Federated Malay States, is given in *Agric. Bull., F.M.S.* (1916, **5**, 44). Seed of six species was sown in January, 1916. Some difficulty was experienced in regard to germination, as the humid climate induced seedlings raised in nursery beds to damp off, and the best results were obtained by sowing in boxes and pots,

although in these cases also there was some loss through the same cause. A number of seedlings were transplanted during the year, and the greatest success was obtained with red gum (*E. rostrata*), one plant in the Public Gardens being 10 ft. high at the end of the year. *E. citriodora* also grew well, but in other cases, including *E. globulus*, *E. populifolia* and *E. crebra*, growth was poor. On the whole the experiment, so far as it has progressed, appears to confirm the results obtained previously at Singapore, that the humid climate of Malaya is unsuitable for most species of Eucalyptus. It is considered, however, that certain species may be grown successfully in the hill districts, and seedlings will be planted at the Experimental Plantation, Gunong Angsi, Negri Sembilan.

The Trees of Formosa.—Although more than half the total area of Formosa is afforested, little has been done to utilise the produce of the forests, with the single exception of camphor, and constructional timber is imported from China and Japan, the former supplying *Cunninghamia sinensis* and the latter *Cryptomeria japonica*. A Forestry Bureau has now been organised by the Government, systematic exploitation of the forests has been begun, and it is hoped that in time the island will be in a position to export timber.

A brief account of the economic trees of Formosa is contributed by the Government forester to the *Indian Forester* (1916, **42**, 410). Three types of forests occur in the mountain zone: (1) evergreen broad-leaved forests, of about 3,000,000 acres; (2) mixed forests of broad-leaved trees and conifers, of about 400,000 acres; and (3) pure coniferous forests of about 670,000 acres. Of these, the coniferous forests are the most important from an economic point of view. In addition to exploiting the existing forests, plantations of exotic trees are being formed. Lists of Formosan trees yielding timber suitable for various purposes are given as well as lists of plants furnishing minor forest products, such as fruits, drugs, fibres, oil seeds, tanning materials, etc.

Timbers

Timber Import Trade of Australia.—At one time considerable quantities of timber were imported into Australia from Canada, but in recent years the trade has declined. With a view to ascertaining the cause of this decline an investigation of Australia's timber import trade has been made by H. R. Macmillan, whose *Report* has been published as a Supplement to the *Weekly Bulletin, Dept. Trade and Commerce, Canada* (Ottawa, 1917). It is considered that the chief causes of Canada's failure in this respect are, firstly, the trans-Pacific timber brokerage and shipping business has hitherto been in the hands mainly of United States companies, with the result that more than half the timber

imported into Australia comes from the United States, and secondly; surplus lumber from the Pacific coast of the States has been dumped abroad under conditions of competition ruinous to many producers, so that Canadian mills have not been attracted to export trade. As regards the first-mentioned cause, Canadian companies, properly equipped to carry on a shipping business, are now entering the field, with results that cannot fail to be of benefit to Canada, whilst as regards the second cause, a stronger organisation of United States mills is now in effect, which promises to prevent the dumping of lumber; and it is suggested that Canadian lumber manufacturers should co-operate with those in the States to control the export market with the object of maintaining prices at a profitable level, adjusting the grades, and exploiting the market for Douglas fir and other North Pacific coast woods. Australia at present imports about half the timber consumed in the country, the value of the imports amounting to nearly £3,000,000 per annum.

Canadian Constructional Timbers.—An account of the characteristics of coniferous woods native to Canada, as well as the chief imported constructional timbers, is given in *Bulletin* No. 59, 1917, *Forestry Branch, Dept. of Interior, Canada.* Chief consideration is devoted to Douglas fir (*Pseudotsuga taxifolia*), one of the most important of Canadian woods, which is shown to be equal to the long-leaf pine (*Pinus palustris*) imported from the United States, for practically all structural or building work, and superior to the other so-called southern pines (*P. taeda* and *P. echinata*). Other woods dealt with include western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), eastern hemlock (*Tsuga canadensis*), western yellow pine (*Pinus ponderosus*), tamarack (*Larix laricina*), red pine (*P. resinosa*) and the spruces (*Picea* spp.). The quantity of each timber available and its distribution are given as well as its characters and uses.

The *Bulletin* also includes an account of the forest resources of the various Provinces of Canada, a discussion of the qualities that affect the usefulness of timber for constructional purposes, and a section on the grading of timber.

ECONOMIC MINERALS

Asbestos.—In *Economic Geology* (1917, **12**, 154) R. P. D. Graham deals with the origin of the massive serpentine and chrysotile asbestos in the Black Lake–Thetford area of Quebec.

Attention is called to the well-defined dyke-like form of the bands of serpentine in the peridotite masses, running in directions parallel to those of the main joints of the latter.

The central part of the massive serpentine bands is usually occupied by chrysotile, and there appears to be a fairly constant relation between the total width of any massive serpentine band and the chrysotile vein it encloses. According to J. A. Dresser, who has made many measurements, the massive serpentine band is about 6·6 times as wide as the asbestos vein within it.

The fibres of a chrysotile vein are usually not continuous across the vein, especially in the wider ones, but there is a parting, or sometimes more than one, at or near the centre, which is occupied by a film of granular iron ore, usually magnetite. Carbonates and quartz are almost completely absent from the serpentines and associated rocks of the area.

Granite is frequently found in the vicinity of good asbestos deposits, and an accumulation of asbestos veins is often noticeable in the neighbourhood of granite dykes. The granite is regarded as having been formed from the same magma as the peridotite, into which it was injected after the peridotite had solidified.

The formation of joint planes in the peridotite, and the serpentinisation of the rock, are supposed to have taken place more or less contemporaneously with the granitic intrusions, and the change to chrysotile was brought about by uprising siliceous waters.

These siliceous magmatic waters permeated the fissures of the cooling peridotite, soaked into the rock, and converted the latter into serpentine for some distance on either side of the fissures.

"Owing to the tendency for the fissures to open, this bordering layer of serpentine was not subjected to a uniform pressure from all directions, and the growing crystals were able to develop only in the direction of least pressure, normal to the fissure. The rock beyond, remaining essentially a solid mass until its serpentinisation became complete, was not materially affected by this circumstance; but as succeeding layers or films further and further removed from the original fissure became completely serpentinised, crystals continued to grow outwards, because it was only at their extremities that they were in contact with fresh supplies of material, and also because the lesser pressure normal to the walls aided their growth in this direction. The original walls of the fissures, and also successive zones or layers of rock beyond, have been in this way continually eaten away and destroyed by the serpentinising waters, and their solution has afforded the material from which the fibres of the chrysotile veins have crystallised; these fibres growing outward as the walls receded further and further through solution."

Fire-clay.—In *Trans. Geol. Soc., South Africa* (1916, **19**, 36), P. A. Wagner describes an outlier of Karroo rocks to the

north of Olifantsfontein station, on the Germiston–Pretoria Railway. The deposit is situated on the farm Olifantsfontein, No. 559, and lies between mile-posts 362¼ and 363¾ on the railway. The clays are used for the manufacture of fire-bricks and earthenware.

In the chief clay-pit the main seam of clay consists of massive pale brown clay which turns white on weathering, and attains a thickness of 6 or 7 ft. Microscopical examination shows that the clay consists chiefly of scaly brownish crystalline material which is regarded as probably an impure form of kaolinite.

In the south-eastern corner of the pit the main seam is underlain by a bed of dark bluish-grey clay which resembles English "ball-clay," and which, when mixed with crushed quartz and china-clay is suitable for the manufacture of white earthenware crockery.

Among other varieties of clay in the pit is a sandy variety which closely resembles Stourbridge fire-clay. It is used in admixture with other clays to make up for their deficiency in free silica. A mixture containing 40 parts by weight of this sandy clay with 60 parts of ordinary clay is made into sewer-pipes at the Olifantsfontein works.

The following are some analyses of representative samples of Olifantsfontein fire-clays from the main pit:

		1. *Per cent.*	2. *Per cent.*	3. *Per cent.*	4. *Per cent.*
Silica	SiO_2	43·64	45·46	45·19	49·01
Alumina	Al_2O_3	39·16	38·36	38·73	33·93
Iron oxides	—	1·53	1·87	0·52	2·63
Lime	CaO	0·30	—	0·26	0·26
Magnesia	MgO	0·34	0·27	0·22	0·32
Alkalis	—	0·47	0·31	0·94	0·62
Sulphur trioxide	SO_3	1·00	0·39	0·01	0·24
Loss on ignition	—	13·56	13·34	14·07	12·99
Volume shrinkage at	100° C.	13·41	22·54	27·19	24·33
" "	1050° C.	20·78	26·82	30·84	35·87
Plasticity in terms of water used		40·00	30·00	44·00	50·00
Fire stability		1780°C.	1640°C.	1730° C.	1650°C.

Sample 4 contained 8·91 per cent. of free silica, and samples 1, 2 and 3 none. The following analyses show the composition of the Olifantsfontein clayey sand compared with Stourbridge fire-clay:

	Clayey sand, Olifantsfontein.	Fire-clay, Stourbridge.
Silica (free)	35·47	65·10
Silica (combined)	28·92	
Alumina	24·44	22·22
Iron oxides	1·74	1·92
Lime	0·30	0·14
Magnesia	0·00	0·18
Alkalis	0·45	0·18
Loss on ignition	8·68	10·40

From the kaolin-like character of the clays and the fact of their inter-stratification with felspathic grits and arkose, it is inferred that they represent the finest muds and silts carried as detritus from an area of coarse granitic rocks, and that the fusible impurities (lime, magnesia, alkalis and most of the iron oxide) were removed in solution during the transportation and deposition of the detritus.

Gold.—In a publication by the Geological Survey of the Union of South Africa (Dept. of Mines and Industries, Pretoria, 1917) E. T. Mellor gives an explanation of the geological map of the Witwatersrand Gold-field. The physical features, principal formations and general geological structure of the area are dealt with, and a brief account of the economic geology is given.

The Witwatersrand is of special interest as the world's most important gold-field. It yields gold to the value of £40,000,000 per annum, or about 40 per cent. of the world's total output. Up to the present date gold to the total value of over £500,000,000 has been produced in this gold-field. Large areas of the gold-field await development. The situation is favourable, and future prospects good.

Coal exists in considerable quantities within the Witwatersrand area, and the coal measures actually overlie the gold-bearing rocks, so that gold-mining and coal-mining can be carried out at different depths in the same locality. The coal-beds are at shallow depth, and can therefore be very cheaply worked.

Other mineral deposits of economic importance in the Witwatersrand area are clays, limestones and building stones.

Graphite.—In *Trans. Geol. Soc., South Africa* (1916, **19**, 54), P. A. Wagner gives an account of some graphite-bearing xenoliths found recently at the Jagersfontein Diamond Mine. They are chiefly olivine-pyroxene nodules. Graphite occurs in them in the form of lustrous flakes and plates up to 8½ millimetres in diameter and a millimetre in thickness. The minerals associated with the graphite, in addition to olivine and enstatite, are pyrope, brown mica and pyrrhotite. It is noteworthy that the graphite appears to have crystallised before the garnet. The garnet is surrounded by reaction rims of brown mica, and is regarded as having crystallised before the olivine and enstatite. The nodules are regarded as of deep-seated origin, and are supposed to represent segregations in the rock from which the kimberlite was derived.

Iron Ore.—In *Trans. Geol. Soc., South Africa* (1916, **19**, 14), A. M. Macgregor deals with the Karroo rocks and later sediments north-west of Buluwayo, and refers to the iron-stone of the Kalahari beds. The iron-stone occurs at the base of a layer of sand, which caps the basalt and which is

found on the top of many of the higher hills in this area. The iron-stone is described as a limonite rock of the type commonly known in South Africa as "laterite." Where it crops out at the surface it has a conglomeratic appearance, with no tendency towards a clayey nature. It has generally a pisolitic texture, and passes into a ferruginous sandstone. Analyses of thirteen samples gave percentages of metallic iron ranging from 22·2 to 50, with an average of 33.

The iron-stone occurs on rocks of different kinds, but has not been derived from these underlying rocks, though the decomposition of the latter has accompanied its formation. It appears that the limonite was leached from the overlying sand, carried to the base where the water stood at the end of the dry season, and precipitated there.

Magnesite.—In the *Rep. Dept. Mines, Western Australia*, 1915, F. R. Feldtmann gives an account of the magnesite deposit at Bulong in the north-east Coolgardie Gold-field. Bulong is about 19½ miles east of Kalgoorlie and 2½ miles west of the western edge of Lake Yinderlgooda. The rocks of this locality are described as a greenstone complex, consisting for the most part of serpentine and gabbro with occasional masses of talcose rocks.

The main area in which magnesite occurs has a length of rather over 2 miles; it varies in width from 25 chains at its northern end to about 10 chains near its southern end, and the total area is about 300 acres. Other smaller magnesite areas lie chiefly to the north of the main area; and one of these, about a mile to the north, occupies a basin about 80 acres in extent.

The magnesite occurs chiefly as short irregular veins in the serpentine rock, and in some places these veins are numerous and closely crowded.

The magnesite has probably been formed for the most part by the action of surface solutions on the serpentine, though it is considered that part of it may have been formed during the alteration of the original constituents of the parent rock (peridotite) into serpentine. In the immediate vicinity of the magnesite veins the surrounding rock is usually much decomposed.

Trial pits put down to varying but shallow depths, down to 12 ft. from the surface, showed veins of magnesite varying up to 2 ft. in thickness. The irregular nature of the deposit, the lack of evidence as to the depth to which it extends, and the fact that much of the area is covered by soil and other detrital material, make it impossible to form any idea of the amount available; but it seems clear that a large tonnage of magnesite containing over 90 per cent. of magnesium carbonate is available.

Molybdenum Ore.—In *Publication* No. 24, 1916, *Mineral Resources Series, Geological Survey, New South Wales*, E. C.

Andrews gives an account of the molybdenite industry of New South Wales. Brief chapters are given to the properties, uses and technology of molybdenum, the concentration of molybdenum ores, the world's deposits of molybdenite, the geology, prospecting and mining of molybdenite deposits. The remainder and greater part of the publication is devoted to a description of deposits and list of localities in which molybdenite occurs in New South Wales.

New South Wales occupies second place in the world's production of molybdenum ores, Queensland being first. In 1915, however, the molybdenite output of New South Wales was only about 32 tons; but it is considered that the output could be largely augmented if necessary, as the State possesses large deposits of low-grade ore which will probably be developed in the near future.

NOTICES OF RECENT LITERATURE

A Historical Geography of the British Dominions. Vol. V. Canada. Part I. Historical. By Sir Charles Lucas, K.C.B., K.C.M.G. 2nd Edition. Pp. 364, Crown 8vo. (Oxford: Clarendon Press, 1916.) Price 6*s.*; post free, United Kingdom and abroad 6*s.* 5*d.*

This volume gives an interesting account of the history of Canada up to its cession to Great Britain in 1763, and, in accordance with the general scheme adopted for the series, aims at tracing the connection between the history and geography of the country.

It describes the manner in which the French gradually established themselves, partially colonised the country and founded a nation. A lucid explanation is given of the various factors which led to their subsequently losing the colony. The author considers that the English conquest was due to the following causes. The English had the better position in North America. The French colonisation took place up the St. Lawrence and other natural lines of communication; the settlers were few in number and the settlements were weak and widely dispersed. The English, on the other hand, formed comparatively continuous seaboard settlements with a climate which was more favourable to European colonisation. In consequence of this advantage there was greater immigration into the English colonies than into the French colony of Canada, and partly for this reason, but even more on account of the exclusion of the Huguenots by the French, the English population largely exceeded that of the French, and at the beginning of the Seven Years' War numbered 1,250,000, whilst the popula-

tion of the French colony was only 100,000. Moreover, when the crisis came, the French devoted their troops and energies primarily to carrying on war in Europe, and thus allowed the English to secure command of the sea and, in consequence, command of the St. Lawrence.

THE RESOURCES OF THE EMPIRE. By J. Watson Grice, D.Sc. (Lond.). Being Volume I. of THE INTERNATIONAL INFORMATION SERIES. Pp. 64, Demy 8vo. (London: The Athenæum Press, 1917.) Price 1*s.* net; post free, United Kingdom and abroad 1*s.* 1*d.*

This book is the first of a series of publications to be issued by the International Information Committee with a view to giving an account of the British Empire in relation to its origin, constitution, resources and general conditions.

In the present work the author briefly reviews the principal resources of the Empire. The first chapter deals with the principal foodstuffs, and shows the proportion of the supplies of the United Kingdom which are derived from British territories and foreign countries respectively. In the second chapter similar information is given with respect to the chief raw materials of our manufacturing industries, such as cotton and other fibres, tanning materials, hides, timber, rubber, dyes and oil seeds. Subsequent chapters are devoted to the mineral resources of the Empire, the capital invested in Empire development, the question of the labour supply and the need of suitable immigrants for the overseas territories, whilst the concluding chapter deals with inter-Imperial trade and the growth of an Imperial economic policy.

INTENSIVE FARMING IN INDIA. By John Kenny, Director of Agriculture, Hyderabad, Deccan. 2nd Edition. Pp. ix + 611, Demy 8vo. (Madras: Higginbothams, Ltd.; London: Luzac & Co., 1916.) Price 8*s.*; post free, United Kingdom 8*s.* 5*d.*, abroad 8*s.* 8*d.*

This book is described in the sub-title as "a manual on the cultivation of rice, cotton, wheat, sugar-cane, tobacco, tea, coffee, coconut, potatoes and onions." The first part discusses the revival of agriculture in India, and reviews what has been done by means of co-operative credit banks and co-operative societies in European countries to further the interests of agriculture. This is followed by first lessons in agriculture, in which the scientific principles underlying agricultural practice are discussed. The remainder of the book, including the chapters on the cultivation of special crops, is devoted to arguing the necessity for manuring the land with artificial manures to supplement the small amount of farmyard manure available for this purpose in India. Very little is said regarding green manuring, which is so

largely practised in India, or as to the value of the various oil-cakes, which are produced locally on a large scale.

SEEDING AND PLANTING: A Manual for the Guidance of Forestry Students, Foresters, Nurserymen, Forest Owners and Farmers. By James W. Toumey, M.S., M.A. Pp. xxxvi + 455, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 15*s.* net; post free, United Kingdom 15*s.* 6*d.*, abroad 15*s.* 8*d.*

The author of this treatise is Director of the Forest School and Professor of Silviculture at Yale University, and was formerly in charge of the nursery and planting work under the United States Forest Service, and more recently was concerned with the organisation of one of the largest commercial forest nurseries in the United States. He is therefore specially qualified to discuss the questions of the raising and planting of forest trees, which are dealt with in the present volume. He maintains that the forester "must have a broad knowledge of methods and tools in order that he may attain successful regeneration at the least cost," and he therefore deals in detail with the fundamental principles that ensure success in the economic production of nursery stock and the artificial regeneration of forests as well as the details of practice. Methods and tools employed in European countries are described as well as those in use in the United States, and as a consequence the book will be of value to foresters in this country as well as in North America.

The subject matter is divided into two parts. The first part is mainly theoretical and deals with general methods of reproduction from seed, the choice of species in artificial regeneration, and the principles which determine the spacing of the trees and the composition of the artificial forests. Part II. is essentially practical and deals with the quality, testing and methods of collecting tree seed, the protection of nursery and plantation sites and treatment of the soil, establishment of forests by direct seeding, care of the nursery and methods of planting. The chapters on seed collection are particularly valuable and deserving of the closest attention, as far too little care is taken by many foresters in the choice of the mother-plant and the quality of the seed.

The book is clearly written and the illustrations and diagrams add greatly to its value.

HANDBOOK FOR RANGERS AND WOODSMEN. By Jay L. B. Taylor, Forest Ranger, United States Forest Service. Pp. ix + 420, Fcp. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1917.) Price 11*s.* 6*d.* net; post free, United Kingdom and abroad 11*s.* 10*d.*

The object of this volume, as stated in the preface, "is

to serve as a guide for inexperienced men in woods work." It is written particularly for the needs of rangers on the United States National Forests, but it will be found useful not only to those whose work takes them into unsettled regions, but to sportsmen and others who visit such places. In addition to information specially applicable to the forester, such as the estimation and felling of timber, cutting and measuring of logs, surveying of forests, combating forest fires, etc., hints are given as to equipment, riding, packing, field cooking, the construction of buildings and fences, laying telephone wires, rock blasting, the care of horses and cattle, the treatment of ailments and injuries, location of camp sites, etc. Tables of weights and measures (including the weight of a bushel of various seeds and vegetables, and of a cubic foot of miscellaneous commodities), log rules, traverse tables, and other miscellaneous information are given in an Appendix. The United States forester apparently prefers to keep to the old systems of weights and measures, as there is no reference anywhere in the book to the metric system. There is a glossary of terms and colloquialisms employed by the forest ranger in the States and a complete index. The illustrations, of which there are 243, consist mainly of outline diagrams, and, although small, are exceptionally clear and instructive.

A Pocket-book for Chemists, Chemical Manufacturers, Metallurgists, Dyers, Distillers, Brewers, Sugar Refiners, Photographers, Students, etc. By Thomas Bayley, A.R.C.S.I. 8th Edition, edited by Robert Ensoll, F.C.S. Pp. xvi + 425, Fcp. 8vo. (London: E. & F. N. Spon, Ltd., 1917.) Price 7*s*. 6*d*. net; post free, United Kingdom and abroad 7*s*. 9*d*.

The present edition of this well-known book will be found even more useful than its predecessors. The whole work has been recast and the tables arranged in a more convenient form. Much obsolete matter has been omitted and many new tables have been added, whilst most of the old tables have been verified. The book is divided into seven sections, designated respectively Mathematical, Weights and Measures, Physical, General Analysis, Gravimetric Analysis, Volumetric Analysis and Miscellaneous, the last including characters of certain chemicals, preparation of solutions of required strengths, freezing mixtures, a glossary of important minerals and photographic data.

A Manual of Field Astronomy. By Andrew H. Holt. Pp. x + 128, Fcp. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1917.) Price 6*s*. net; post free, United Kingdom and abroad 6*s*. 3*d*.

This book is intended for the use of students, and of engineers and surveyors in practice, who occasionally

require to make astronomical observations. It is essentially practical, and the discussion of the theoretical part of the work is made as brief as possible. Separate chapters are devoted to the measurement of time, problems in the conversion of time, corrections to observations, and observations for latitude, azimuth, time and longitude. In connection with the observations, the theoretical basis of the work is first dealt with briefly and the method of procedure is then outlined under the general headings: "Computations Preceding Field Work," "Field Work," and "Computations Following Field Work." This outline is supplemented by specimen field notes and computations of a similar observation.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial, and Indian Governments concerned.

ECONOMIC PRODUCTS FROM CYPRUS

The results of examination of a series of products, including cotton, spices, essential-oil-yielding plants, foodstuffs, fodders and drugs, received at the Imperial Institute from Cyprus in 1916, are given in the following article. A good deal of information regarding similar materials from Cyprus has already been published in previous numbers of this BULLETIN, to which the following references may be given: Origanum oil (1906, **4**, 296; 1908, **6**, 208; 1910, **8**, 407); marjoram oil (1913, **11**, 50); "juniper," laurel leaf, "mint," myrtle and "sage" oils (1913, **11**, 428–33); barley (1914, **12**, 552; 1916, **14**, 159); tobacco (1915, **13**, 547); flax (1908, **6**, 4); sumach (1912, **10**, 45); Acacia barks (1913, **11**, 412); wool (1912, **10**, 537); minerals (1906, **4**, 205); asbestos (1912, **10**, 307); magnesite (1912, **10**, 138); salt (1916, **14**, 37).

Cyprus is essentially an agricultural country, and most of the exports consist of the produce of the soil. The chief agricultural products, with the total quantity produced in 1915, are shown in the following table:

Wheat	1,750,000 bushels.	Olives	59,756 cwts.
Barley	1,900,000 ,,	Grapes	479,719 ,,
Oats	375,000 ,,	Carobs	245,914 ,,
Cotton	23,982 cwts.	Pomegranates	115,396 ,,
Silk cocoons	651,207 lb.		

The chief exports of agricultural products from Cyprus and the total value of all exports in 1915 were as follows:

	Unit of quantity.	Quantity.	Value. £
Carobs	cwts.	944,980	203,162
Barley	bushels	466,000	68,371
Oats	"	58,000	6,425
Wheat	"	120[1]	42
Lemons and oranges	number	14,852,906	13,235
Pomegranates	cwts.	117,130	20,250
Raisins	"	54,189	34,467
Cotton	"	6,251	16,306
Silk cocoons	lb.	161,924	37,299
Wool	cwts.	5,493	14,523
Hides and skins	"	913	4,686
Wines	gallons	1,313,610	38,158
Total value of all exports			661,397

[1] *This quantity is exceptionally low; in* 1913 88,000 *bushels of wheat, valued at* £17,661, *were exported.*

The Agricultural Department, which was reconstituted on a permanent basis in 1913, is at work in many directions, and through the Agricultural School, the summer vacation courses for schoolmasters, the village agricultural societies and the advisory work of the travelling instructors, is steadily increasing its influence with the local farmers, who in spite of their natural conservatism are beginning to respond more readily to its advice. The Department is experimenting with the introduction of new crops, particularly fodders and foodstuffs, of which lucerne and rye are now being grown by the farmers. Work is also being done on the improvement of vine and olive cultivation, the introduction of new varieties of cotton, tobacco, etc., sericiculture, bee-keeping, and remedial measures against insect pests and fungoid diseases.

Cotton

Experiments were continued by the Agricultural Department in 1915 with exotic varieties of cotton. Three kinds, Allen's Improved Long Staple, Mebane's Early Triumph, both improved American Upland varieties, and Sakellarides, an Egyptian variety, were grown at Ashia, Nicosia and Akaki, and a fourth variety, New Orleans, a long-stapled American cotton, which is in fairly general cultivation in Cyprus, was grown at Nicosia in addition.

On the whole the Triumph cotton gave the best results, and many growers in the Ashia district, where cotton is now cultivated over a larger area than in any other part of the island, have applied to the Department for seed of this variety. The Triumph cotton not only gave the best yield of lint, but it matured earlier than the other varieties tried. The detailed results of the experiments are shown in the following table:

Variety.	Yield of lint per acre.		
	Ashia.	Nicosia.	Akaki.
	lb.	*lb.*	*lb.*
Allen's Improved, imported seed	237	152	271
,, ,, , seed produced in Cyprus from seed imported in previous year	275	136	169
Mebane's Early Triumph, imported seed	373	271	373
Sakellarides, imported seed	237	220	169
New Orleans, seed produced in Cyprus from seed imported many years previously	—	119	—

The plots at Ashia and Akaki were each about $\frac{1}{12}$ acre in size, and at Nicosia about $\frac{1}{6}$ acre. They were manured at the following rates: 110 lb. nitrate of soda, 212 lb. superphosphate and 34 lb. sulphate of potash per acre.

Samples of the Allen's Improved, Mebane's Early Triumph and Sakellarides cottons produced in the course of these experiments were received at the Imperial Institute and were examined with the following results:

No. 1. *Allen's Improved.*—Soft, fairly lustrous, cream-coloured cotton, free from stains and immature fibre, but rather "neppy." It was of fairly good strength, and varied in length from 0·9 to 1·5 in., being mostly about 1·3 in.

The lint was valued at 17·0*d.* per lb., with "middling" American cotton at about 12*d.* per lb. (November 1916).

This sample was quite similar to good samples of "Allen's Improved long-staple cotton" received at the Imperial Institute from other countries.

No. 2. *Mebane's Triumph.*—Fairly soft, cream-coloured cotton, of little lustre and free from stains and immature fibre. The strength of the fibres was fairly good, and the length ranged from 0·7 to 1·2 in., being mostly from 0·9 to 1·0 in.

This cotton was valued at 12·5*d.* per lb., with "middling" American cotton at about 12*d.* per lb. (November 1916).

This sample possessed the usual characters of American Upland Triumph cotton.

No. 3. *Sakellarides.*—Soft, cream-coloured cotton, of little lustre. The sample was free from stains, but a fair proportion of immature fibre was present. The strength was uneven, but on the whole good. The length varied from 1·0 to 1·8 in., being mostly about 1·5 in.

This sample was valued at 17·5*d.* per lb., with "G.F. medium Sakellarides cotton" at 24·9*d.* per lb. and "middling" American cotton at about 12*d.* per lb. (November 1916).

This cotton was somewhat "neppy." Judging from its appearance it had been ginned with a saw gin. Cotton of this type should be freed from seeds in a roller gin. The rather low valuation is due to the poor lustre of the cotton and the somewhat high proportion of immature fibre present.

ANISEED

Aniseed, the fruit of an umbelliferous herb (*Pimpinella Anisum*, Linn.), is grown on a comparatively small scale in Cyprus, the exports in recent years varying from 1,000 to 2,000 cwts. per annum. In 1915 1,112 cwts., valued at £1,823, were exported, all of which went to Egypt. For an account of the cultivation and uses of aniseed see this BULLETIN (1913, **11**, 127).

The sample examined at the Imperial Institute consisted of aniseed in good condition and practically free from extraneous matter.

The seeds were examined as a source of volatile oil, the residue remaining after distillation being analysed as a feeding-stuff. The results were as follows:

(1) On steam distillation the ground seeds yielded 2·8 per cent. of a pale yellow volatile oil having the characters of oil of aniseed. The oil was examined with the following results, compared with commercial oil of aniseed:

	Present sample.	Commercial anise oil.
Specific gravity at $\frac{15° C.}{15° C.}$	0·990	0·975 to 0·990
Optical rotation in a 100 mm. tube	0°	0° to −2°
Refractive index	1·557 at 24° C.	1·552 to 1·558
Solubility in 90 per cent. alcohol	Soluble in 2·8 vols. at 15° C.	Soluble in 3 to 5 vols.
Solidification point	+17·5° C.	+15° to +19° C.

The yield of oil from the present sample of seeds and the constants of the oil are normal.

(2) The residue remaining after removal of the volatile oil was examined with the following results:

	Per cent.		Per cent.
Moisture	6·0	Starch, etc. (by difference)	26·9
Crude proteins	21·3	Fibre	10·9
Consisting of—		Ash	5·2
True proteins	19·3		
Other nitrogenous substances	2·0	Nutrient ratio [1]	1:4·5
Fat	29·7	Food units [2]	154

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

No alkaloids or cyanogenetic glucosides were present in the material.

Residues from the distillation of aniseed are used as a feeding-stuff, and the residue left by the Cyprus product would be quite suitable for this purpose.

A sample of the seed was submitted to brokers in London, who stated that at that time (January 1917) stocks of aniseed were quite exhausted, and the prices therefore much inflated, small stocks of Spanish aniseed having changed hands in London at 110*s.* per cwt. Such prices could not be secured if any quantity of aniseed were placed on the market. The value of the Cyprus sample before the war would have been about 27*s.* 6*d.* per cwt.

Coriander Seed

Coriander seed is the product of *Coriandrum sativum*, Linn., an annual herb belonging to the Natural Order Umbelliferæ (cf. this Bulletin, 1913, **11**, 129).

The sample examined consisted of seed having the usual appearance of coriander seed, but containing from 6 to 7 per cent. of extraneous matter consisting chiefly of small lumps of clay.

As in the case of the sample of aniseed the seeds were examined as a source of volatile oil, and the residue remaining after distillation was analysed as a feeding-stuff.

(1) On steam distillation the ground seed yielded 0·48

per cent. of an almost colourless volatile oil with the characteristic and pleasant odour of coriander. This yield is below that furnished by Russian and German coriander, but is about equal to that obtained from Morocco seed. The oil was examined with the following results, in comparison with those recorded for commercial coriander oil.

	Present sample.	Commercial sample.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$ . .	0·879	0·870 to 0·885
Optical rotation in a 100 mm. tube	+12° 20′	+[illegible] to 14°
Refractive index	1·467 at 20° C.	1·463 to 1·467 at 25° C.
Solubility in 70 per cent. alcohol	1 in 1·9 or more vols. at 15° C.	1 in 3 vols. or less at 20° C.

(2) The residue remaining after removal of the volatile oil was examined with the following results:

	Per cent.		Per cent.
Moisture	6·5	Starch, etc. (by difference) .	26·7
Crude proteins . . .	12·8	Fibre	29·2
Consisting of—		Ash	9·2
True proteins . .	11·5		
Other nitrogenous substances . .	1·3	Nutrient ratio . .	1 : 4·9
Fat	15·6	Food units	98

No alkaloids or cyanogenetic glucosides were present in the material.

The above results indicate that this residue has a fairly high feeding value, and it would be quite suitable for the ordinary use of coriander residue, *i.e.* as a cattle food.

A sample of the seeds was submitted to brokers in London, who reported that they were very stalky, but that their value would be from 50*s.* to 60*s.* per cwt. (January 1917) as compared with 10*s.* to 15*s.* per cwt. before the war.

White Cumin Seed

White cumin is also an umbelliferous herb (*Cuminum Cyminum*, Linn.); an account of its cultivation and uses is given in this Bulletin (1913, **11**, 131).

The sample received at the Imperial Institute consisted of seed having an average length of ⅕ in. About 3 per cent. of extraneous matter, consisting of small globular seeds somewhat resembling the dried seeds of a species of *Galium*, was present.

The material was examined as a source of volatile oil, and the residue remaining after distillation was analysed as a feeding-stuff, with the following results:

(1) On steam distillation the ground seed yielded 3·4 per cent. of bright yellow volatile oil, with the strong characteristic odour of cumin oil. The oil was compared with oil made in Cyprus and examined at the Imperial Institute early in 1916, and also with commercial cumin oil:

	Present sample.	Previous sample.	Commercial cumin oil.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$.	0·956	0·953	0·90 to 0·93
Optical rotation in a 100 mm. tube . . .	+ 1° 30′	+ 1° 39′	+ 4° to + 8°
Refractive index . . .	1·510 at 23°C.	1·514	1·497 to 1·509
Solubility in 80 per cent. alcohol	Soluble in 1·1 vol.	Soluble in 1·2 vol.	Soluble in 3 vols. (lighter oils in 4 to 10 vols.)
Aldehydes . *per cent.*	52	47	20 to 30

This seed is of good quality, giving an average yield of oil, which, however, is abnormally rich in "aldehydes."

(2) The residue remaining after removal of the volatile oil gave the following results on analysis:

	Per cent.		*Per cent.*
Moisture	8·7	Starch, etc. (by difference)	27·9
Crude proteins . . .	17·6	Fibre	10·2
Consisting of—		Ash	5·6
True proteins . .	17·2		
Other nitrogenous substances . .	0·4	Nutrient ratio— .	1 : 5·5
Fat	30·0	Food units	147

No cyanogenetic glucoside was found in the material, but a trace of alkaloid appeared to be present.

The composition of this residue indicates a high nutritive value, and it is probable that the material could be utilised for feeding cattle, but actual trial would be necessary before it could be recommended for this purpose.

A sample of the seed was submitted to brokers in London, who stated that it was rather small and stalky, but that it would probably be worth between 70*s.* and 80*s.* per cwt. (January 1917), although they were of opinion that its pre-war value would not have been much over 20*s.* per cwt.

Black Cumin Seed

These seeds, sometimes known as fennel-flower seeds, are the product of *Nigella sativa*, Linn. (Nat. Ord. Ranunculaceæ). The plant is an annual, native to the Mediterranean region, and the seeds, which are used in the East for flavouring curries, etc., and in Egypt as comfits on cakes, have an aromatic fennel-like odour when fresh and a slightly acrid taste. There is a small export of black cumin seed from Cyprus, 63 cwts., valued at £80, being sent to Egypt in 1915.

There is no market for black cumin seed in the United Kingdom, but these Cyprus seeds were examined as a matter of general interest.

On steam distillation the ground seeds yielded 0·3 per cent. of a reddish-brown oil, with a disagreeable odour. The quantity of oil obtained was insufficient for chemical examination, but the unpleasant odour makes it certain that the volatile oil is of no commercial value.

The residue remaining after removal of the volatile oil was examined with the following results:

	Per cent.
Moisture	5·1
Crude proteins	19·9
Consisting of—	
True proteins	19·6
Other nitrogenous substances	0·3
Ether extract (fat, etc.)	45·2
Starch, etc. (by difference)	21·0
Fibre	4·8
Ash	4·0

No cyanogenetic glucoside was found in the sample, but a minute trace of an alkaloid appeared to be present. A poisonous glucoside of the saponin class—melanthin—is said to exist in the seeds (Wehmer, *Die Pflanzenstoffe*, p. 198).

On examination of the seeds as a source of fixed oil they were found to contain 8·0 per cent. of moisture and to yield 41·2 per cent. of a dark brown liquid oil, equivalent to a yield of 44·8 per cent. from the dry seeds. The oil deposited some solid "stearin" on standing.

The oil was submitted to chemical examination with the following results;

Specific gravity at $\frac{100° C.}{15° C.}$		0·8614
Solidifying point of fatty acids		22·3° C.
Acid value[1]		101·2
Saponification value[1]		198·0
Iodine value	*per cent.*	123·8
Unsaponifiable matter	*per cent.*	0·9

[1] *Milligrams of potash for 1 gram of oil.*

The oil rapidly becomes acid when the seeds are ground and allowed to stand.

Black cumin seed has occasionally been used in Europe as a spice, but this use seems to have become obsolete, and there is now no regular market for the seed in this country. The seed yields a large quantity of fixed oil, but this possesses a pronounced flavour and odour and is of dark brown colour. These characteristics are against the use of black cumin seed as an oil seed except in cases where there is a great scarcity of other oil seeds.

It does not seem advisable to extend the cultivation of black cumin seed in Cyprus, and it would be preferable to give attention to the cultivation for export of other spices, such as white cumin, aniseed and coriander. There is a large demand in this country and throughout Europe for these spices, so that they are always readily saleable, whereas black cumin will not be readily marketable.

A New Cyprus Origanum (*O. Bevani*)

The ordinary origanum oil produced in Cyprus, of which 34 cwts., valued at £1,046, were exported to the United Kingdom in 1915, is obtained by the distillation of *Origanum dubium*, Boiss. In 1913 herbarium specimens of a species of Origanum found near Lapithos and known locally as "rikhanon" were received at the Imperial Institute. The plant was subsequently described by Holmes as a new species, *O. Bevani* (*Perf. and Ess. Oil Record*, 1915, **6**, 19). It was suggested by the Imperial Institute that a supply of the dried herb of this species should be sent from Cyprus in order that the volatile oil which it yields might be investigated and its value ascertained. In accord-

ance with this suggestion a supply of 49 lb. of dried plants in flower, but without the roots, was forwarded in August 1916. The material had a characteristic thyme-like aroma.

The material as received contained 9·8 per cent. of moisture and yielded 1·9 per cent. of volatile oil. This yield of oil is only about half that obtained from ordinary Cyprus origanum. The oil, which when first distilled was pale yellow, but soon deepened to a reddish-brown colour, had a characteristic odour of thyme. It was submitted to chemical examination with the following results, in comparison with those obtained for samples of ordinary origanum oil from Cyprus examined at the Imperial Institute:

	Origanum Bevani oil.	Ordinary Cyprus origanum oil.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·951	From 0·958 to 0·966
Optical rotation	+0° 24′	0°
Refractive index at 23° C.	1·51	1·51
Phenols . . . *per cent.*	75	From 75 to 82·5
Solubility in 70 per cent. alcohol	Soluble in 2·7 vols. at 15° C.	Soluble in from 1·4 to 2·8 vols. at 15° C.

The phenols in the present sample appeared to consist chiefly of a mixture of carvacrol and thymol, in the proportion approximately of 41 parts of carvacrol and 34 of thymol. This oil therefore differs from ordinary Cyprus origanum oil in giving a slightly lower percentage of phenols, and in containing a mixture of carvacrol and thymol in place of carvacrol alone.

The oil would be more useful if it contained thymol alone, as it would then be possible to use it as a source of this important antiseptic.

Samples of the oil prepared at the Imperial Institute were submitted, together with the results of examination quoted above, to firms of soap-makers and manufacturing perfumers. One of these firms estimated its value at 75 per cent. of that of Spanish thyme oil, then worth 5*s.* to 7*s.* per lb. The second firm valued the oil at 5*s.* to 6*s.* per lb., and stated that it would probably sell readily in place of oil of thyme.

It will be seen from the foregoing results that *O. Bevani* is not likely to be so profitable to volatile-oil distillers in Cyprus as ordinary Cyprus origanum, since the latter

yields nearly twice as much oil and the oil is at least equal in value to that of *O. Bevani*. Moreover, it appears that *O. Bevani* is very sparsely distributed in Cyprus, so that special steps would have to be taken to encourage its production if it were desired to distil oil from it on a commercial scale. In view of these facts it seems clear that attention should continue to be directed in Cyprus to the production of ordinary origanum oil, and that no attempt should be made at present to utilise this new species as a source of oil.

Chick Peas

Chick peas or gram (*Cicer arietinum*) are grown extensively in all parts of India, and are used locally for human consumption and for feeding cattle; before the war, large quantities were exported to Europe from India for the latter purpose.

A sample received from Cyprus consisted of rounded seeds measuring about ⅜ in. in diameter and having a wrinkled exterior of a pinkish-buff colour. The sample was clean, dry and in good condition.

The seeds were examined with the following results, compared with chick peas from India and Nyasaland:

	Present sample.	Chick peas from India.	Chick peas from Nyasaland.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·3	11·5	8·8
Crude proteins	21·7	21·7	22·8
Consisting of—			
True proteins	18·6	—	20·4
Other nitrogenous substances	3·1	—	2·4
Fat	6·1	4·2	4·9
Starch, etc. (by difference)	57·7	59·0	57·1
Fibre	1·6	1·0	3·5
Ash	2·6	2·6	2·9
Nutrient ratio	1 : 3·3	1 : 3·2	1 : 3
Food units	127	124	126

No alkaloids or cyanogenetic glucosides were present in the sample.

The results of examination show that these peas are of normal composition.

The sample was submitted to two firms of produce brokers in London, who stated that if quantities of about

5 tons at a time could be delivered in this country in as good condition as this sample they could be sold for human consumption, and would be worth £20 to £24 per ton c.i.f. United Kingdom ports under present conditions (February 1917).

If, however, the deliveries were not as good as the present sample, the peas would be sold for feeding cattle, in which case the price would depend on the quantities of competing materials available. At present chick-peas from India are selling in this country as a feeding-stuff at £15 to £15 10*s.* per ton.

Oats

This sample consisted of light straw-coloured grains of good appearance. Some dirt and straw were present in the sample.

After removal of the extraneous matter the oats were examined with the following results:

	Present sample. *Per cent.*	Figures recorded for commercial oats. *Per cent.*
Moisture	8·4	13·3
Crude proteins	8·9	8·2 to 12·7
Consisting of—		
True proteins	7·9	—
Other nitrogenous substances	1·0	—
Fat	6·0	4·2 to 5·6
Starch, etc. (by difference)	59·0	49·9 to 63·2
Fibre	13·2	8·1 to 15·0
Ash	4·5	3·0 to 3·5
Nutrient ratio	1 : 8·2	1 : 4·9 to 1 : 8·9
Food units	96	94 to 96

The composition of these Cyprus oats is about normal. A sample was submitted to produce brokers in London, who stated that the oats were rather thin, but that there would probably be a fair demand for them in this country if they could be offered at 45*s.* 6*d.* to 46*s.* per quarter of 320 lb. (February 1917).

Oat Straw

This material consisted of chopped-up straw and chaff, the straw forming the larger portion of the sample, which was in clean and dry condition.

The results of examination, expressed on the material as

received, were as follows, compared with corresponding figures recorded for oat straw:

	Present sample.	Figures previously recorded for oat straw.
	Per cent.	*Per cent.*
Moisture	8·9	15·1
Crude proteins	2·6	4·0
Consisting of—		
True proteins	2·1	—
Other nitrogenous substances	0·5	—
Fat	1·6	1·5
Starch, etc. (by difference)	41·8	38·6
Fibre	32·3	35·6
Ash	12·8	5·2
Nutrient ratio	1 : 17·5	1 : 10
Food units	52	52

This material is poor in proteins and contains a high proportion of ash owing to the chaff present. On account of its relatively soft character and ease of digestion, oat straw is regarded as one of the most valuable of the cereal straws for feeding purposes, and the material represented by the present sample should be satisfactory for that purpose.

Kyko Oat Plant

The sample of Kyko oat plant from Cyprus which is the subject of this report was forwarded in accordance with a suggestion made by the Imperial Institute that the value of the plant as a fodder should be ascertained. Specimens of this oat plant and its seeds had been received at the Imperial Institute in 1915. They were submitted to Kew, where plants raised from the seed were identified as *Avena sativa* var. *obtusata*, Alef. This plant is a form of banner-oat commonly cultivated in South-Eastern Europe and also in France, where it is variously known as Avoine blanche de Hongrie, de Pavolie, de Turquie, or de Russie.

The material received in August 1916 had been cut in the green state and consisted of oat plants, freed from roots, and measuring from 5 to 6 ft. in length, including the heads, which were about 1 ft. long. The plants consisted chiefly of straw-coloured stems, with a few pale green or straw-coloured leaves, and pale greenish heads of undeveloped fruits.

The sample was submitted to chemical examination at

the Imperial Institute, and the results, expressed on the material as received, are shown below, in comparison with a recorded analysis of oats in flower:

	Present sample.	Figures recorded for oats in flower.
	Per cent.	*Per cent.*
Moisture	8·8	11·5
Crude proteins	5·4	7·5
Consisting of—		
True proteins	3·7	—
Other nitrogenous substances	1·7	—
Fat	1·3	2·4
Starch, etc. (by difference)	40·0	42·4
Fibre	35·2	30·1
Ash	9·3	6·1
Nutrient ratio	1 : 8	1 : 6·4
Food units	57	67

No alkaloids or cyanogenetic glucosides were present in the sample.

The foregoing results indicate that the Kyko oat plant has only a slightly lower feeding value than the ordinary oat plant of which the analysis is recorded above, and the product should be a useful fodder for cattle.

White Cumin Chaff

This material consisted of fine, chopped stems of a greenish-straw colour, together with a small quantity of seeds. It had an aromatic smell. The sample was slightly dirty but otherwise in good condition.

The results of examination expressed on the material as received are shown in the following table, compared with figures recorded for average good meadow hay and oat straw:

	Present sample.	Average good meadow hay.	Oat straw.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·6	14·3	15·1
Crude proteins	9·6	9·3	4·0
Consisting of—			
True proteins	7·3	—	—
Other nitrogenous substances	2·3	—	—
Fat	4·6	1·5	1·5
Starch, etc. (by difference)	46·6	41·3	38·6
Fibre	16·5	26·8	35·6
Ash	12·1	6·8	5·2
Nutrient ratio	1 : 6	1 : 4·7	1 : 10
Food units	82	68	52

No alkaloids or cyanogenetic glucosides were present in the sample.

The results of analysis indicate that this white cumin chaff has a fairly high nutritive value, but the material has not a promising appearance as a fodder as it consists chiefly of hard, slender stems. Its suitability for the purpose can only be determined by actual feeding trials. If, however, it is eaten with relish by stock and no injurious after effects are observed, it should, judging from its composition, form a useful fodder for local use.

Squill Bulbs

The squill is said to be very common in many parts of Cyprus, but the bulbs do not appear to be collected and prepared on a commercial scale. Specimens of the entire bulb, in fresh condition, were received at the Imperial Institute in August 1916.

The bulbs measured from about 4 to 4½ in. in length, and from 3 to 3½ in. in diameter, and each bore a green shoot about 1 in. long.

The bulbs were submitted to Kew, and identified provisionally as *Urginea Scilla*. It is proposed to grow the plant at Kew and thus verify or, if necessary alter, this provisional identification later on.

Samples of the bulbs and of dried slices prepared from them at the Imperial Institute were submitted to drug manufacturers and merchants in London, who reported on them as follows:

A firm of drug manufacturers stated that the bulbs would not find a market in the United Kingdom, as squill is only bought in the dried sliced state. The dried, sliced product of the present sample, however, would not be saleable in any case, owing to its dark colour. The firm supplied for guidance a reference sample of the commercial product, and stated that material of the quality and colour of this reference sample would be worth about 6*d*. per lb. (February 1917) against a pre-war value of only 3*d*. per lb.

A firm of merchants confirmed the opinion quoted above, and furnished reference samples of the "good" and "low" quality as at present imported from Catania, Sicily,

The following prices have recently been obtained for squills sold in London:

January 13th, 1917: "White," 50*s.* per cwt.

January 13th, 1917: "Brown," 45*s.* per cwt.

March 8th, 1917: "Fair white," 55*s.* per cwt.

There are two varieties of *Urginea Scilla*, white and red, the scales of the former being yellowish-white and those of the latter having a reddish tint, and there are also many intermediate forms. Though the red and the white varieties have been stated to possess equal medicinal value, the white variety is preferred in England, and comes into the market in flattish curved strips 1 to 2 in. long.

The British Pharmacopœia describes squill as "yellowish-white strips," and the official squill in the United States is the white variety. The present sample is apparently of the red variety and therefore does not meet the requirements of the British and United States Pharmacopœias.

Information was also supplied to the Cyprus authorities as to the variety required and the method of preparing squill bulbs for the market.

Liquorice Root

The liquorice plant (*Glycyrrhiza glabra*, Linn., Nat. Ord. Leguminosæ) occurs wild in some parts of the north and east shores of Cyprus, and the roots are collected and exported in small quantities from time to time. Two samples of the root were received at the Imperial Institute as follows:

(1) "*Lapethos.*"—This sample consisted of unpeeled liquorice roots from ⅜ to 1 in. in diameter and from 5 to 9 in. long. The pieces were brown and wrinkled externally, and yellow and fibrous within.

(2) "*Famagusta.*"—This sample generally resembled No. 1, but the roots measured from ¼ to ¾ in. in diameter and from 4 to 9 in. in length.

The samples were submitted to chemical examination with the following results:

	Sample from Lapethos. *Per cent.*	Sample from Famagusta. *Per cent.*
Moisture	8·4	7·7
Ash	7·8	6·0
Extract on maceration with chloroform water	27·1	23·6
Glycyrrhizin	10·2	9·9

The samples were submitted to two firms of brokers in London, who reported on them as follows:

(*a*) One firm described the Lapethos roots as medium to bold unpeeled roots of good flavour, fairly well cleaned and very well dried, and valued them at from 50*s.* to 55*s.* per cwt. ex wharf London (February 1917). The firm described the Famagusta roots as thinner than the Lapethos sample and not so well freed from smooth valueless pieces, but mentioned that they had apparently been washed. They valued these roots at 50*s.* per cwt., ex wharf London (February 1917).

The firm added that both samples were exceptionally dry, and that it seemed doubtful if the material in bulk would be as dry. They pointed out that to prevent the roots becoming mouldy it was very important that they should be properly dried before packing. They recommended shipping the roots in press-packed bales of from 3 to 4 cwts. each.

(*b*) A second firm considered the roots to be of rather mixed inferior quality, and worth at the present time about 45*s.* per cwt. in London (February 1917). They suggested that a trial consignment of the material should be forwarded to test the market.

"WILD OLIVE" FRUITS FROM SOUTH AFRICA

The so-called "wild olive" is the fruit of *Ximenia americana*, Linn., a bush or small tree belonging to the Natural Order Olacaceæ, and found widely distributed in tropical Africa, India, Ceylon, Brazil, West Indies and the tropics generally. The fruit is a drupe, about the size and shape of an olive. According to Watt (*Dict. Econ. Prod. India*) the fruit, which is known also as "wild lime," "mountain plum," "seaside plum," "citron of the sea," etc., is eaten by the natives when ripe; Schweinfurth states that its flavour is like that of a citron and that it is extremely sour; Welwitsch says it smells of prussic acid and that no animal touches it; but Safford (*Plants of Guam*) states it is much relished by a species of dove in Guam. There is similar diversity of opinion as to the character of the kernel of the fruit. Watt

says the kernels are eaten and taste like filberts; Schweinfurth, Welwitsch and others also refer to them as being edible, but other authors describe them as purgative or as poisonous. The fruits are stated by several authors to yield prussic acid (*e.g.* Ernst, *Arch. Pharm.*, 1867, 181, 222); no trace of cyanogenetic glucosides could be found in a sample of the leaves of this plant from the Sudan examined at the Imperial Institute in 1908 or in the kernels (see p. 316).

A specimen of the bark from the Sudan, examined at the Imperial Institute some years ago, was found to contain 16·9 per cent. of tannin, and furnished a soft leather with a rather reddish colour (this BULLETIN, 1907, 5, 359).

A sample of the fruits of *X. americana* obtained from trees growing in the Northern Transvaal was received for examination at the Imperial Institute in November 1916. It consisted of small fruits measuring 1 to 1⅛ in. in length and ½ in. in diameter, with a small amount of dried reddish pulp adhering to them. The nuts left after removal of the pulp had thin, brittle, pinkish-brown shells, and oval kernels ¾ to 1 in. long and ⅜ to ½ in. in diameter; the shells constituted 25 per cent. and the kernels 75 per cent. of the nuts.

The kernels were covered with a soft, dry, pinkish-buff pulp; they were of cream colour and of a soft oily consistency.

The average weight of the entire fruits was 1·6 gram, and of the kernels 1·2 gram.

Kernels.—The kernels as received at the Imperial Institute contained 3·4 per cent. of moisture, and yielded 65·6 per cent. of oil on extraction with light petroleum and 65·8 per cent. on extraction with acetone, equivalent to yields of 67·9 and 68·1 per cent. respectively from the dry kernels. The oil in each case was yellow and slightly cloudy, the cloudiness disappearing on warming. It was also viscous, the oil extracted with light petroleum being much more viscous than that extracted with acetone.

Oil.—The oils were submitted to examination with the following results, compared with figures recorded for oil from the kernels of *X. americana* from German East Africa (*Der Pflanzer*, 1913, 9, 354) and elsewhere (Grimme, *Chem. Rev. Fett- u. Harz-Ind.*, 1910, 17, 156):

	Present sample.		Figures recorded for the oil of *X. americana* from German East Africa.			Figures recorded by Grimme.
	Oil extracted with light petroleum.	Oil extracted with acetone.	Expressed oil.	Oil extracted with ether.	Oil extracted with acetone.	—
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·9231	0·9220	0·9205	0·9220	0·9210	0·9248
Acid value[1]	2·1	1·6	10·5	11·76	12·0	1·2
Saponification value[1]	170·4	172·7	173·6	173·2	177·0	183·1
Iodine value *per cent.*	93·6	88·8	81·3	85·1	80·3	84·0
Unsaponifiable matter, *per cent.*	2·9[2]	—	—	—	—	2·9

[1] *Milligrams of potash for* 1 *gram of oil.*
[2] *Including* 2 *per cent. of a rubber-like substance.*

The yield of oil from the kernels agrees with that recorded previously for *X. americana* kernels in *Der Pflanzer*—viz. 65 to 67 per cent. Grimme found that the kernels contained 63·82 per cent. of oil, and Heckel (*Ann. Inst. Col. Marseilles*, 1898, 5, 27) by extraction with carbon disulphide obtained a yield of 69 per cent. The oils extracted at the Imperial Institute did not possess any sharp after-taste, such as is mentioned in *Der Pflanzer*, probably because they were prepared from fresher kernels.

The expression of the oil from the seeds is stated in *Der Pflanzer* to be difficult, and extraction with solvents is recommended.

The oil is non-drying, and could probably be used for lubricating, soap-making and other purposes, but the presence of a rubber-like substance renders it very viscous, and technical trials on a large scale would be necessary in order to ascertain whether it could be used industrially.

Residual Meal.—The residual meal left after the removal of the oil by means of solvents consisted of a fine, greyish-white, practically odourless meal, having a mild flavour and an after-taste suggesting that of garlic. It was analysed with the following results, compared with those recorded for linseed meal and decorticated cotton-seed meal, and with the press-cake of *X. americana* from German East Africa as calculated from the composition of the kernels (*Der Pflanzer*, 1911, 7, 485):

	Present sample of meal.	Press-cake of *X. americana.*	Linseed meal.	Decorticated cotton-seed meal.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	6·2	7·2	13·2	7·4
Crude proteins	38·8	41·5	34·8	42·4
Consisting of—				
True proteins	33·4	—	—	—
Other nitrogenous substances	5·4	—	—	—
Fat	5·3	5·0	3·0	10·2
Starch, etc. (by difference)	38·1	31·3	34·7	25·9
Fibre	6·3	8·9	8·7	7·0
Ash	5·3	6·1	5·6	7·1
Nutrient ratio	1 : 1·3	1 : 1·03	1 : 1·2	1 : 1·16
Food units	148	147	129	157

The meal examined at the Imperial Institute contained no cyanogetic glucosides, whilst *Der Pflanzer* (*loc. cit.*, p. 484) also states that a search for prussic acid in the seeds gave negative results.

It will be seen that *X. americana* meal is rich in proteins, containing a higher percentage than extracted linseed meal, though somewhat less than an average quality of decorticated cotton-seed meal. Feeding trials carried out in Germany with several kinds of animals are stated (*Der Pflanzer*, *loc. cit.*, p. 486) to have shown that the meal is not well suited for use as a feeding stuff, and further trials would therefore be necessary to decide this question.

These *X. americana* kernels are rich in oil, but the presence of a rubber-like substance renders the value of the oil uncertain. Trials on a fairly large scale would be necessary to determine (1) the best means of obtaining the oil from the seeds, (2) the uses to which the oil could be put, and (3) the suitability of the residual meal for use as a feeding stuff. Such trials would, however, only be warranted if the material is obtainable in quantities sufficient to allow of a regular supply of the kernels, and in districts where they could either be easily worked in the locality or shipped for export.

The rubber-like substance present in the oil is not of a promising character as a rubber substitute, but in the event of any considerable quantity becoming available as a by-product in the extraction of the oil it should be tried for compounding purposes in rubber manufacture.

THREE NEW OIL SEEDS FROM WEST AFRICA

The West African oil seeds dealt with in the following pages were received at the Imperial Institute in the early part of 1917. The botanical sources of the seeds are not known with certainty, and information as to the quantity of seed procurable is not at present available.

N'Gore Nuts

The sample consisted of almost spherical nuts, bluntly pointed at one end and measuring from ¾ to 1 in. in diameter. The nuts consisted of 41 per cent. shell and 59 per cent. kernel. The kernels were brown externally, of soft consistence, and mostly of pale cream colour within. Many of the kernels were in poor condition and of dark brown colour.

These nuts are possibly derived from *Ongokea Gore*, Pierre (Nat. Ord. Olacaceæ) but it is not possible to determine their identity from the fruits alone. The characters of the oil obtained from the nuts agree with those recorded by Hébert for the oil of *Ongokea Gore* (*Bull. Soc. Chim.*, 1896, **15**, 935).

1. *Oil.*—The kernels contained 6·3 per cent. of moisture and yielded 66·2 per cent. of a reddish-yellow viscous oil, equivalent to a yield of 70·7 per cent. from the dry kernels. The oil, which had an unpleasant smell, was submitted to chemical examination with the following results:

Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$		0·987
Solidifying point of fatty acids		below 8° C.
Acid value[1]		17·7
Saponification value[1]		190
Iodine value	*per cent.*	153
Hehner value, approximately		83
Insoluble fatty acids	*per cent.*	80·2
Unsaponifiable matter	*per cent.*	2·8
Volatile acids, soluble[2]		1·0
„ „ , insoluble[2]	(approx.)	12·0
Acetyl value		85·5

[1] *Milligrams of potash for* 1 *gram of oil.*

[2] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of fat.*

This oil has an unusually high specific gravity. It is partially soluble in alcohol and completely so in ether, but it is not soluble in light petroleum, although it absorbs this solvent to some extent. In respect of its high specific gravity, viscosity and behaviour with solvents, it is somewhat similar to castor oil, and the acetyl value shows that like castor oil it contains hydroxylated acid. Although the oil has a high iodine value it does not dry on exposure to air in a thin film.

The unpleasant smell and viscous nature of the oil, together with its dark colour, would prevent its use for edible purposes. It yields a dark-coloured soap, but could no doubt be used for making certain kinds of soap. It might also prove useful as a lubricating oil, and could probably be utilised for several purposes to which castor oil is applied.

2. *Residual Meal.*—The residue left after extraction of the oil consisted of a cream-coloured meal, having a faint but somewhat unpleasant garlic-like taste. The meal was submitted to chemical examination with the following results:

	Per cent.		*Per cent.*
Moisture	6·8	Starch, etc. (by difference)	26·9
Crude proteins	43·4	Fibre	8·8
Consisting of—		Ash	7·1
True proteins	37·6	Nutrient ratio	1 : 1
Other nitrogenous substances	5·8	Food units	153
Fat	7·0		

No alkaloids or cyanogenetic glucosides were present in the meal.

The above results indicate that this N'gore meal has a high nutritive value, but owing to its peculiar character further examination and feeding trials would be necessary in order to ascertain whether it could be used safely as a feeding stuff for animals.

The N'gore kernels furnish a large yield of oil which is of an unusual type but may prove to be of considerable technical value.

N'kamba Nuts

This sample consisted of pale brown nuts, measuring $1\frac{1}{4}$ in. in length and 1 in. in diameter. The nuts had a woody shell about $\frac{1}{12}$ in. thick enclosing a brown kernel 1 in. in length and $\frac{3}{4}$ in. in diameter, with a hard buff-coloured interior. The shell formed 37 per cent. and the kernel 63 per cent. by weight of the nut.

The characters of these N'kamba nuts agree with those of specimens previously received at the Imperial Institute, which were identified at Kew as belonging to a species of *Heisteria* (Nat. Ord. Olacaceæ), but it is not possible to determine their exact botanical source from the fruits alone.

1. *Oil.*—The kernels contained 11·3 per cent. of moisture and yielded 14·5 per cent. of a yellow liquid oil, equivalent to a yield of 16·3 per cent. from the dry kernels. This yield is much lower than has been recorded by Heckel for the kernels of *Heisteria Trillesiana* from Gaboon, viz. 48 per cent., and it seems probable that the N'kamba nuts are derived from a different species of *Heisteria.*

The oil was submitted to chemical examination with the following results:

Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$		0·931
Solidifying point of fatty acids		17° C.
Acid value		26·1
Saponification value		194·8
Iodine value	*per cent.*	93·2
Hehner value		94·5
Insoluble fatty acids	*per cent.*	93·4
Unsaponifiable matter	*per cent.*	1·1
Volatile acids, soluble		2·05
" " , insoluble		0·95

The oil is of a non-drying character and could no doubt be used for various industrial purposes. The yield from the kernels is, however, so small that the latter would be of little value as a commercial source of oil.

2. *Residual Meal.*—The residue left after the extraction of the oil from the kernels consisted of a cream-coloured meal having a pleasant and rather sweetish taste. It was submitted to chemical examination with the following

results, which are shown in comparison with those recorded for a sample of palm-kernel meal:

	N'kamba meal. *Per cent.*	Palm-kernel meal. *Per cent.*
Moisture	6·2	15·0
Crude proteins	18·9	19·0
Consisting of—		
True proteins	15·5	—
Other nitrogenous substances	3·4	—
Fat	1·3	2·0
Starch, etc. (by difference)	68·4	51·0
Fibre	2·4	9·0
Ash	2·8	4·0
Nutrient ratio	1 : 3·8	1 : 2·9
Food units	119	104

No alkaloids or cyanogenetic glucosides were present in the N'kamba meal.

The above results indicate that N'kamba meal should have a nutritive value about equal to that of palm-kernel meal. The meal appears, however, to contain saponin, as it causes frothing when shaken with water, and an attempt to gain further evidence on this point will be made. There appears to be no record of the use of Heisteria meal as a feeding stuff, and as it may contain saponin, which is an undesirable constituent, it cannot be recommended for this purpose.

A further sample of these kernels was received in July 1917, and on examination was found to contain 18·1 per cent. of oil, calculated on the dry kernels, as compared with 16·3 per cent. in the case of the first sample. Two specimens of nuts from the Belgian Congo, which were very similar in appearance to N'kamba nuts, have also been received at the Imperial Institute; they contained 15·6 and 13·2 per cent. of oil respectively, expressed on the dry kernels. In view of the low yield of oil and the doubtful quality of the meal it is improbable that these kernels would be of value in this country, at any rate under present conditions.

Strephonema Kernels

These kernels from the Belgian Congo were received from the Belgian Minister of the Colonies in January 1917. They were stated to be Strephonema kernels, but the

species was not given. Strephonema is a small genus of trees and shrubs placed by Bentham in the natural order Lythraceæ, and by Engler in the Combretaceæ. The genus is confined to tropical West Africa.

The sample consisted of very dark brown kernels, roughly hemispherical in shape and measuring from 1 to 1½ in. in diameter. Internally the kernels were hard, and of purplish-brown colour. They contained 7·7 per cent. of moisture, and were found to yield 38·6 per cent. of a bright yellow, rather soft fat, equivalent to a yield of 41·8 per cent. from the dry kernels. The fat was free from unpleasant smell or taste. On chemical examination it gave the following results:

Specific gravity at $\frac{100° C.}{15° C.}$		0·8596
Solidifying point of fatty acids		57° C.
Acid value		8·0
Saponification value		181·1
Melting point of fat		29° C.
Neutralisation value of fatty acids		183·2
Glycerin	*per cent.*	6·9
Optical rotation		nil
Iodine value	*per cent.*	67·0
Unsaponifiable matter	*per cent.*	0·5
Volatile acids, soluble		0·9
„ „ , insoluble		0·2

The low saponification value is unusual for a fat of this character. This feature is probably due to the presence of a considerable amount of fatty acid having a low saponification value, and not to the presence of di-glycerides. The yield of glycerin is somewhat low, and would be much higher if di-glycerides were present.

The residual meal left after the extraction of the oil was of chocolate colour and had an unpleasant astringent taste. It was analysed with the following results:

	Per cent.
Moisture	7·3
Crude proteins	9·5
Consisting of—	
True proteins	8·2
Other nitrogenous substances	1·3
Fat	0·9
Starch, tannin, etc. (by difference)	69·9
Fibre	9·1
Ash	3·3

No alkaloids or cyanogenetic glucosides were present.

A considerable quantity of tannin is present as the following results show, and the astringent taste of the meal is no doubt due to this:

		Per cent.
Moisture		7·3
Matter insoluble in water		44·3
Extractive matter (non-tannin)		17·7
Tannin		30·7
Ash		3·3
Tintometer readings for a 0·5 per cent. tannin solution in a 1 cm. cell	Red	7·4
	Yellow	15·9

The meal thus contained a fairly large amount of tannin, but the extract was of a dark purple-red colour, and would yield a dark-coloured leather, so that it seems unlikely that the meal would be of commercial value either as a tanning material or for the manufacture of tanning extract.

The results of this investigation indicate that the yield of fat from these Strephonema kernels is sufficient to make them of commercial value. In order, however, for oil seeds to sell readily, especially in the United Kingdom, it is necessary that they should yield a good feeding cake, and the presence in the meal of a considerable amount of dark-coloured tannin would prevent its use for feeding purposes without special preliminary treatment for the removal of the tannin. It would not appear to be worth while to consider the question of devising such special means of treatment unless the kernels are available in large quantities.

A POSSIBLE NEW SOURCE OF THYMOL

BEFORE the war thymol was obtained commercially only from ajowan oil, distilled from ajowan seeds (*Carum copticum*, Benth.), which were exported for this purpose from India to Germany. As this country was entirely dependent on Germany for its supplies of thymol there was a considerable scarcity of this antiseptic soon after the outbreak of hostilities. Attention was called to the subject in an article published in this BULLETIN (1914, 12, 599) in which it was suggested that the manufacture of thymol should be undertaken in the United Kingdom, and reference was made to a

number of other plants which yield oils containing thymol, and which might possibly be suitable as sources of that material. Since then thymol has been manufactured on a commercial scale in this country from ajowan seed imported from India and from Spanish oil of thyme. Its manufacture from ajowan seed has also been undertaken in India.

Among the plants referred to in the article mentioned as possible commercial sources of thymol was *Ocimum viride*, Willd. (Nat. Ord. Labiatæ). This plant is a much-branched perennial, which in a wild state reaches a height of 3 ft. to 6 ft. It is native to West Africa, but has been introduced into India, Cyprus and the West Indies. It is frequently known as "mosquito plant," on account of its supposed property of keeping off these insects. Several specimens of *O. viride* leaves from Nigeria and Sierra Leone have been examined at the Imperial Institute, and the yield of oil obtained on distillation ranged from 0·35 to 1·2 per cent.; the quantity of thymol contained in the oil was found to vary from 32 to 65 per cent. in the different samples.

With a view to ascertaining the possibility of growing *O. viride* on a commercial scale for the production of thymol, seed was obtained from the Department of Agriculture, Sierra Leone, by the Imperial Institute, and distributed to Seychelles, Cyprus and the East Africa Protectorate, in which countries facilities already exist for the distillation of essential oils. The plant has grown well in Seychelles, and two samples of oil distilled locally have been examined at the Imperial Institute. The results of their examination are given in the present article.

In the case of the *O. viride* grown in Seychelles the seedlings were transplanted into good garden soil when 2 months old, and at the end of 8 months from the time of sowing the bushes were 6 ft. high. A trial distillation of the leaves was made in a small laboratory still in October 1916, during the dry season. The plants, which were then 4 months old, had just started flowering, and some of the leaves were collected after the seeds had ripened. The yield of oil from the leaves was 0·5 per cent. A further cutting was made in the rainy season, when the

plants were 8 months old. In this case the upper 8 in. of the shoots were distilled, that is, the green portions above that part of the stem which turns brown; the inflorescences were not separated from the leaves and twigs before distillation. The yield of oil was 0·45 per cent. of green material, and the total yield of oil per acre was estimated to be 16 kilograms (about 35 lb.), the yield of green material from one cutting being reckoned at 3,550 kilos. (nearly 3½ tons) per acre. It is expected that several cuttings, possibly 5 or 6, can be made per annum, but this point has not yet been definitely settled. A sample of each oil produced in Seychelles was received at the Imperial Institute, and these were examined with the following results.

1. *Oil distilled from leaves.*—This sample weighed about 1½ oz., and consisted of oil which, as received, was cloudy, owing to the presence of moisture. When freed from moisture it was of a yellowish-brown colour, and had a thyme-like odour.

2. *Oil distilled from green shoots.*—This sample weighed about 4 oz. and consisted of pale yellowish-brown oil with a thyme-like odour.

The two samples of oil were found to have the following constants, compared with samples of *O. viride* oil previously received from Sierra Leone:

	Samples from Seychelles. No. 1.	Samples from Seychelles. No. 2.	Samples from Sierra Leone.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·942	0·924	0·911
Optical rotation a_D	+ 1° 5′	+ 0·6°	~~+ 1° 20′~~
Phenols . . *per cent.*	62	52	up to 65
Solubility in alcohol	Soluble in 3·1 volumes of 70 per cent. alcohol at 15° C.	Insoluble in 20 or less volumes of 70 per cent. alcohol, but soluble in 1·4 volume of 80 per cent. alcohol at 15° C.	—

The phenols in both samples of the oil appeared to consist entirely of thymol, much of which separated out even at ordinary atmospheric temperatures. It will be seen, however, that sample No. 2 contains a lower percentage of thymol than sample No. 1, the amounts of phenols being 52 and 62 per cent. respectively.

The first sample of oil was too small for trial as a source of thymol and for valuation. Specimens of No. 2 were submitted to soap-makers and to manufacturing chemists, who reported on it as follows:

(*a*) The soap-makers stated that they had carried out experiments with the oil, but that it was exceedingly difficult to quote any definite value for it. They found the oil to be different in type from either Spanish or French thyme oils, and they considered it doubtful whether it would command a price equal to that of the cheaper of these two oils, *i.e.* the Spanish. The firm stated that the odour of the oil is not altogether unsatisfactory at first, but that its persistence is low, and the final odour has an unpleasant smoky character which is entirely different from that of the thyme oils ordinarily used.

The firm, however, expressed their willingness to carry out further experiments with it in comparison with the thyme and origanum oils which they employ at present, and the Seychelles authorities have been asked to send a further sample for this purpose.

(*b*) A firm of manufacturing chemists stated that at the present market price of thymol they estimated the value of this *O. viride* oil at from 5*s.* to 6*s.* per lb., delivered free in London. They mentioned that this was an approximate price and that a definite valuation could only be given after making a large-scale trial to ascertain the cost of extracting the thymol.

It will be seen from the foregoing report that this *O. viride* oil should be a useful source of thymol if it can be marketed at a suitable price. It was therefore suggested to the Seychelles Government that the cultivation of the plant should be continued in the Colony, and it was recommended that a trial consignment of several cwts. of the oil should be forwarded to London for sale.

INDIAN HENBANE

REFERENCE has been made previously in this BULLETIN (1903, **1**, 175; 1916, **14**, 202) to the occurrence in India of *Hyoscyamus muticus*. This plant is now the chief source

of atropine, commercial supplies being obtained from Egypt and the Sudan (*loc. cit.*, 1916, **14**, 22). A sample of the Indian material, examined at the Imperial Institute some years ago, contained only 0·1 per cent. of total alkaloid, which is much less than the amount found in Egyptian henbane. Barnes has stated (*Agric. Journ. India*, 1916, **11**, 86) that a specimen of Indian Hyoscyamus (probably *H. muticus*), examined by him, contained 0·827 per cent. of mydriatic alkaloids, expressed on the dried plant. A sample grown at the Koilpatti Agricultural Station, Madras, was received for examination at the Imperial Institute in September 1916. It consisted of typical *H. muticus* stems averaging about 2 ft. in length, with leaves and persistent calyces attached, together with a small proportion of loose leaves and small stems.

The material as received was found to contain 10·94 per cent. of moisture. A representative portion was partially dried and finely ground, and was found to contain 8·14 per cent. of moisture and 0·61 per cent. of total alkaloid, equivalent to a yield of 0·66 per cent. of total alkaloid expressed on the dry material.

The total alkaloid was readily obtained in a crystalline condition, and on further examination proved to consist of hyoscyamine.

It was pointed out to the Indian authorities that, in view of the results quoted above, it is desirable that the experimental cutivation of this henbane should be continued, and that as soon as possible a trial shipment should be sent to London for sale.

BAOBAB WOOD AND BARK FROM SOUTH AFRICA

THE samples of baobab wood and bark which are the subject of this report were forwarded to the Imperial Institute from South Africa in February 1917. It was desired to ascertain the value of the materials for paper-making. The baobab (*Adansonia digitata*, B. Juss., Nat. Ord. Bombacaceæ) is of common occurrence in tropical

Africa and India, and has been introduced into the West Indies. The fibre extracted from the inner bark is used by natives for making ropes and sacking, and small quantities occasionally reach this country from West Africa for use in the manufacture of paper.

I. Wood

The sample consisted of split logs up to about 2½ ft. in length. The wood was soft, very light and brittle, of pale-yellow colour and slightly attacked by mould.

On drying in the air the wood lost 36 per cent. of moisture, and then gave the following results on examination:

Moisture	*per cent.*	10·2
Ash, expressed on the dry wood . .	"	4·4
Cellulose, " " " . .	"	52·5
Length of ultimate fibres	0·7 to 3·2 mm.; mostly about 1·5 to 2·5 mm.	

The wood was examined as a paper-making material by the soda process with the following results:

	Caustic soda. Parts per 100 parts of wood.	Caustic soda. Parts per 100 parts of solution.	Conditions of boiling. Time.	Conditions of boiling. Temperature.	Soda consumption per 100 parts of wood.	Yield of dry pulp, expressed on the air-dry wood. *Per cent.*
A .	16	4	5½ hrs.	140° C.	10	48
B .	14	4	6 hrs.	140° C.	10	50

The unbleached pulp thus obtained was of light brown colour, and yielded a paper which shrank slightly on drying and was opaque, hard and fairly strong. The pulp could not be bleached by the usual process, the colour being only slightly improved on treatment with a large excess of bleaching powder.

This air-dried baobab wood gave a good yield of pulp, which furnished a brown paper of fair strength. The pulp, however, did not bleach well, though it is possible that more drastic treatment by boiling with soda and subsequent washing would enable a bleachable pulp to be obtained. In this case, however, the yield of pulp would be reduced. The wood could certainly be used for paper or pulp manufacture, but the pulp does not possess the good qualities of that prepared from the inner bark of the tree (see p. 329).

II. Bark

This consisted of pieces which included both the hard brown outer bark and the greyish fibrous inner bark. The outer bark consisted mainly of masses of thick-walled woody (sclerenchymatous) cells.

The bark lost 23 per cent. of moisture on drying in the air, and then gave the following results on examination:

Moisture	*per cent.*	9·2
Ash, expressed on the dry bark . . .	,,	14·0
Cellulose, ,, ,, ,, . . .	,,	44·0
Length of ultimate fibres	1·0 to 4·6 mm.; mostly 1·7 to 2·4 mm.	

The entire bark was examined as a paper-making material by the soda process, with the following results:

Caustic soda.		Conditions of boiling.		Soda consumption, per 100 parts of bark.	Yield of dry pulp, expressed on the air-dry bark.
Parts per 100 parts of bark.	Parts per 100 parts of solution.	Time.	Temperature.		*Per cent.*
14	4	5 hrs.	140° C.	11	27

This experiment yielded a dark-brown pulp which contained a large quantity of hard, gritty particles. Microscopical examination showed that these particles consisted of sclerenchymatous cells derived from the outer bark. In another experiment, in which the amount of caustic soda used was increased to 16 per cent. of the weight of the bark, these sclerenchymatous cells were not softened or broken up, and it was not found possible to remove them from the pulp by washing. The paper produced from the pulp made from the whole bark was so rough as to be practically useless, and the pulp did not bleach satisfactorily.

In order to obviate the presence of the gritty particles, the outer bark was removed and the inner fibrous bark alone used. The entire bark after air-drying yielded 37 per cent. by weight of inner bark, which was converted into pulp by the soda process with the following results:

Caustic soda.		Conditions of boiling.		Soda consumption, per 100 parts of inner bark.	Yield of dry pulp, expressed on the air-dry inner bark.
Parts per 100 parts of inner bark.	Parts per 100 parts of solution.	Time.	Temperature.		*Per cent.*
20	4	5 hrs.	140° C.	16	33

The pulp thus obtained was of dark greyish-brown colour, and produced a strong opaque paper. The pulp, however, did not bleach satisfactorily.

The yield of pulp obtained from the present sample of inner bark, viz. 33 per cent., is decidedly low, probably owing to the presence of pithy matter in the sample, as the clean inner bark usually contains about 60 per cent. of cellulose. Baobab bark is usually prepared for paper-making by removing the outer bark and then stripping off the inner bark in large sheets, which are thoroughly beaten in order to remove pithy matter. It is not feasible to do this after the bark has been dried, as in the present case.

The pulp prepared from the inner bark was of excellent quality, and should be very suitable for the manufacture of strong brown wrapping paper. It did not bleach easily, however, and further experiments under different conditions would be necessary in order to ascertain whether a bleachable pulp can be made from the material. The present sample was insufficient for this further investigation.

Conclusions

The results of this examination of baobab wood and bark from South Africa show that pulp of excellent quality can be prepared from the inner bark, but that it would not be possible to use the entire bark for the purpose.

The pulp obtained from the wood is of poorer quality than that yielded by the inner bark, and its possible utilisation for paper-making is less certain. Owing to the light bulky character of the wood the cost of transportation would be heavy, and the wood could not be remuneratively exported as a paper-making material.

SUNFLOWER STEMS FROM RHODESIA

THE sunflower is at present being grown on a comparatively small scale in Rhodesia for the production of seed. Its cultivation is increasing, however, and the crop gives promise of doing well in the country. According to information supplied to the Imperial Institute by the Director of Agriculture at Salisbury, several farmers grow areas of

from 30 to 200 acres of sunflower, and many cultivate it on a smaller scale for home use. In 1916 the total area under sunflower amounted to 1,766 acres, and 500 tons of seed were harvested, the average yields in districts best suited to the crop being over 800 lb. per acre. The price realised for the seed is stated to be too low for the crop to be a very attractive one, and it was thought that if an additional profit could be made out of the stems the inducement to grow this crop would be much enhanced. In July 1916 a sample of sunflower stems was sent from Rhodesia to the Imperial Institute in order to ascertain whether the pith contained in the stems would find a market in the United Kingdom, and especially whether it was suitable for such purposes as the manufacture of buoyant life-saving apparatus and for packing in the sheathing of ships. The stems were also investigated at the Imperial Institute as a source of paper pulp and of potash. The stems sent were stated to represent material which could be supplied in large quantities, probably hundreds of tons, the crop ripening in April and May.

The sample consisted of the main stems of the sunflower plant, measuring about 6 ft. in length, about 1½ to 1¾ in. in diameter at the root, and ½ to ¾ in. at the top. The central portion of the stems was filled with a firm white pith.

1. *Pith*

The stems were found to contain 18 per cent. of their weight of pith, which had a specific gravity of 0·043—*i.e.* it was about a quarter the weight of cork. A portion of the pith after being completely immersed in water for 12 days was not completely water-logged, although at the end of that period it only just floated.

On ignition the pith burned without any flame and smouldered slowly.

As compared with "sola" pith, derived from *Aeschynomene aspera* from India, which is used for sun-helmets, the present material had a slightly greater specific gravity (0·043 as compared with 0·040), and it was much firmer. "Sola" pith burns rapidly on ignition.

The pith was analysed with the following results, which

are shown in comparison with the figures recorded for maize and elder pith :

	Sunflower pith (present sample).		Maize pith.			Elder pith.
Yield of pith from stems *per cent.*	18		20			—
	(A) *Per cent.*	(B) *Per cent.*	(C) *Per cent.*	(D) *Per cent.*	(E) *Per cent.*	(F) *Per cent.*
Moisture in pith as received	9·3	10·8	—	—	—	—
Constituents of the dry pith :						
Ash	18·6	20·2	3·0	4·5	4·5	1·9
Proteins	3·4	—	3·8	3·5	3·3	2·5
Fat	1·1	—	1·2	5·6	1·4	1·2
Carbohydrates (digestible)	55·1	—	47·4	52·8	48·4	25·3
Crude fibre	21·8 [1]	—	44·6	33·6 [1]	42·4	69·1
Matter soluble in hot water	—	34·8	—	—	—	—
Cellulose	—	29·3 [1]	—	51·6 [1]	39·9 [2]	41·9 [2]
Nitration, loss on	—	21·0	—	—	—	—

(A) and (B) in the above table represent two different portions of pith, each taken from a few stems of the present sample.

[1] *The fact that the percentage of cellulose in these cases is higher than the percentage of crude fibre is to be attributed to the loss of material due to hydrolysis by boiling with acid in the determination of the percentage of crude fibre.*

[2] *Determinations on crude fibre residue.*

From the above figures it will be seen that sunflower pith is somewhat similar in composition to maize pith, but it contains a much larger amount of ash and less cellulose. It should have a higher feeding value than maize pith, but it cannot be recommended for use in feeding-stuffs without trial, in view of American experience that the feeding value of maize *stalks* is in practice improved by the removal of the pith, which is less digestible than the remainder of the stalk, and is objectionable on account of its high absorptive properties (*Bulletin* No. 50, *Division of Chemistry, U.S. Dept. Agric.*, p. 27). It is, however, by no means certain that a feeding-stuff cannot be prepared from it (see p. 334).

It has been suggested in the United States that piths of this type might be employed as sources of cellulose products, including explosives; but it is clear from the foregoing results that this sunflower pith would be of little value for such purposes, partly owing to the physical character of the pith, but chiefly owing to its low yield of cellulose. The materials commonly employed as sources of cellulose are waste cotton (after careful purification) and wood, both

of which are cheaper and more convenient to handle than this pith and give higher yields.

Samples of the pith were submitted to manufacturers of explosives and of pith helmets, with the following results:

(1) The explosives manufacturers stated that the pith possessed no absorptive power for nitro-glycerine, and would therefore be of no interest to the explosives industry from that point of view as a substitute for wood flour. As a combustible ingredient of a composite explosive it might, however, possess advantages over other carbonaceous materials now in use, but this could only be determined by practical trial. If the pith were found suitable for this purpose its value in the United Kingdom in normal times would probably be between £3 and £6 per ton.

(2) A firm of pith helmet manufacturers stated that the fibre of the present sample was too short and too brittle to be used in place of the imported pith (sola pith) used in their works.

2. *Entire Stems*

The whole stems were chopped up and submitted to treatment similar to that employed in paper mills for the production of paper pulp. The following conditions of experiment were found necessary for the production of pulp:

	Caustic soda used.		Conditions of boiling.		Soda consumption per 100 parts of stems.	Yield of dry pulp, expressed on the stems as received.
	Parts per 100 parts of stems.	Parts per 100 parts of solution.	Time.	Temperature.		*Per cent.*
A .	18	4	6 hrs.	150° C.	16	38
B .	22	4	6 hrs.	150° C.	17	37

The pulp thus obtained was of dark colour and yielded a fairly tough, opaque, parchment-like paper of fair quality, which shrunk a good deal on drying. The pulp did not bleach to a pure white colour, and even when much larger quantities of bleaching chemicals were used than could be employed on a commercial scale it only yielded a yellowish paper. The use of a larger quantity of caustic soda did not improve the quality of the pulp.

With a view to ascertaining whether the removal of the

pith would improve the quality of the pulp, the stems were chopped and the pith removed as far as possible by scraping and winnowing. On a practical scale the greater part of the pith could be removed by merely winnowing the stems after chopping. The woody material thus obtained gave the following results:

Caustic soda used. Parts per 100 parts of stems.	Caustic soda used. Parts per 100 parts of solution.	Conditions of boiling. Time.	Conditions of boiling. Temperature.	Soda consumption per 100 parts of stems.	Yield of dry pulp.
					Per cent.
[1] 18	4	8 hrs.	150° C.	17	44
[2] 14·76				14	36

[1] *Expressed on the weight of stems used, with pith removed.*
[2] *Expressed on the weight of entire stems used.*

The paper thus produced from the stems freed from pith was distinctly superior to that yielded by the whole stems. The pulp, however, showed the same characteristics when attempts were made to bleach it.

3. *Ash from the Stems*

The stems, as received, contained 10·3 per cent. of moisture, and yielded 10·7 per cent. of ash, which had the following composition:

		Per cent.
Potash	K_2O	49·6
Soda	Na_2O	2·3
Phosphoric acid . . .	P_2O_5	1·5

The dry stems must therefore contain nearly 5 per cent. of their weight of potash, and if chopped up fine and used as a manure they would be a useful source of potash, in addition to supplying humus and a small amount of phosphoric acid and nitrogen to the soil. The fact that sunflower stems are rich in potash is well known, and in Southern Russia, where sunflowers are grown on a large scale for the production of seed, the stems are burned, and the ash used for the production of potash. This Russian potash industry, which is of considerable importance commercially, is described in a pamphlet on *The World's Supply of Potash*, published by the Imperial Institute (1915, p. 29) and also in an article on the "Cultivation and Utilisation of Sunflower Seed" in this BULLETIN (1916, **14**, 92). During the war, and until a better

method of disposing of the sunflower stems has been discovered, the stems might well be burned in Rhodesia, and either the ash, or crude potash made from it, exported to the United Kingdom.

Summary and Conclusions

1. *Pith.*—Practically the only industrial purpose to which plant pith is applied at the present time is in the manufacture of pith helmets. For this purpose sunflower pith appears to be less suitable than the sola pith now employed, but further enquiries on this point are being made. The pith cannot be employed as a substitute for wood and cotton for the preparation of cellulose, owing to its low yield of cellulose and its physical condition. It is not a promising material for packing in the sheathing of ships and for stuffing life-saving appliances for use at sea.

Maize pith has been regarded as unsuitable for use in feeding-stuffs, owing to its indigestibility and its high absorptive capacity for fluids. No experiments appear to have been made with feeding-stuffs containing sunflower pith, and it would appear to be worth while to try such experiments in Rhodesia. The pith would probably be greatly improved for this purpose if it were ground and mixed with molasses to make a material similar to the feeding-stuffs now largely used, and which are made by mixing molasses with the soft inner portion of the sugar cane.

2. *Whole Stems.*—When the pith is removed the stems give a good yield of pulp, which, however, cannot be satisfactorily bleached, and is only suitable for the manufacture of common brown paper. The best method of using the stems at present would appear to be either to chop them fine for use as a manure, since they contain nearly 5 per cent. of potash, or to burn them and use the ash, which contains nearly 50 per cent. of its weight of potash, as a rich potash manure, or employ it for the extraction of crude potash as is now done in Russia.

SPECIAL ARTICLE

THE CONSTITUTION AND WORK OF THE IMPERIAL INSTITUTE, WITH SPECIAL REFERENCE TO MINERAL RESOURCES

THE Imperial Institute was constituted a Government Institution by the Imperial Institute (Transfer) Act of 1903, its principal duty being to promote by various means the development of the natural resources of the Empire. Under the Imperial Institute (Management) Act of 1916 the management of the Institute is vested in the Secretary of State for the Colonies, the actual government of the Institute being carried on by an Executive Council of twenty-five members, including representatives appointed by the Governments of the Dominions, India and the Colonies. These countries, as well as the United Kingdom, contribute to the financial support of the Institute. In conducting the general business of the Institute the Executive Council is assisted by a Finance and General Purposes Committee and by other Committees appointed from its members.[1]

Advisory Committees have been appointed for each Dominion and for India. These Committees include representatives with special knowledge of the trade and industry of their countries. Each High Commissioner in London is the Chairman of the Committee for his Dominion.

Advisory Technical Committees, including commercial, technical and scientific specialists, have been appointed for various raw materials. The Mineral Resources Committee consists of:

Brigadier-General G. K. COCKERILL, C.B. (nominated by the War Office).

Sir ROBERT HADFIELD, Bart., F.R.S., lately President of the Iron and Steel Institute, President of the Faraday Society.

Prof. J. W. GREGORY, F.R.S., Professor of Geology in the University of Glasgow, formerly Director of the Geological Survey of Victoria, Australia.

[1] A list of the Council and of the Committees was given in the first number of the present volume of this BULLETIN (1917, **15**, x–xv).

Dr. F. H. Hatch, Ph.D., F.G.S., Consulting Mining Engineer, formerly President of the Institution of Mining and Metallurgy.

Mr. G. T. Holloway, A.R.C.S., F.I.C., Consulting Metallurgist, Vice-President of the Institution of Mining and Metallurgy, Chairman of the Ontario Nickel Commission.

Sir Richard Redmayne, K.C.B., H.M. Chief Inspector of Mines, lately President of the Institution of Mining and Metallurgy (nominated by the Home Office).

The Right Hon. Lord Rhondda, lately Managing Director, Cambrian Collieries, Ltd.

Admiral Sir Edmond Slade, K.C.V.O., K.C.I.E. (nominated by the Admiralty).

Mr. W. J. Glenny, Commercial Intelligence Department, Board of Trade (nominated by the Board of Trade).

Prof. Wyndham R. Dunstan, C.M.G., F.R.S., Director of the Imperial Institute.

Dr. T. A. Henry, Imperial Institute, Secretary.

This Committee since its appointment has fully considered the operations of the Imperial Institute in connection with mineral resources, and has issued a Report and recommendations for future work. The principal recommendations are:

That the work of the Imperial Institute on minerals should be continued and extended in order to provide for the supply of full information respecting the mineral resources of the Empire;

That the staff engaged on the several divisions of this work should be added to;

That the present arrangements for communication and co-operation with Departments of Mines, etc., overseas should be continued and extended;

That the articles on mineral resources hitherto published in the Bulletin of the Imperial Institute should in future be published separately, and that a Mineral Year Book giving statistical and other information on mineral resources should be issued.

The Committee further recommend that the work of the Imperial Institute should be principally directed to obtaining full information as to the mineral resources of the Empire, their extent and composition, and to suggesting to the Governments concerned the steps which should be taken to develop mineral deposits of value hitherto undeveloped.

The Committee consider that information as to new developments in processes of mining and metallurgy should be separately collected and published by co-operation between the special societies concerned with these subjects.

Co-operation with the Board of Trade and with the Association of Chambers of Commerce

The Board of Trade nominates two representatives on the Executive Council of the Imperial Institute and the Association of Chambers of Commerce of the United Kingdom one representative.

In connection with the Imperial Institute Act of 1916, an inter-departmental Committee sat to arrange the respective spheres of work of the Board of Trade and the Imperial Institute in the supply of commercial intelligence respecting raw materials, including minerals. The principal recommendation of the Committee, which was accepted by the Departments concerned, was to the effect that enquiries and investigations relating to the sources of supply of the raw materials of the Empire and their utilisation should be dealt with by the Imperial Institute.

In order to facilitate the introduction into British commerce and industry of raw materials, including minerals, which have been investigated by the Imperial Institute, the Association of Chambers of Commerce has nominated representatives of the principal Chambers throughout the country to serve on the Raw Materials Committee of the Imperial Institute, of which the President of the Association (Sir Algernon Firth, Bart.) is Chairman. The following Chambers are represented on this Committee: London, Manchester, Glasgow, Liverpool, Bristol, Norwich, Hull and Middlesbrough.

The Committee meets periodically at the Imperial Institute to consider reports and to advise as to the action to be taken in bringing new raw materials which have been examined and reported on by the Imperial Institute to the notice of merchants and manufacturers through the Chambers of Commerce, and by the publication of information in the journals of these Chambers throughout the country.

Staff and Operations for Minerals

There is a special staff initiated under the Act of 1903 and now numbering twelve officers, with laboratories and assay rooms for mineral investigations, whether geological, mineralogical, or involving chemical analysis and assay, as well as assistants trained in the indexing and collection of commercial, statistical and technical information regarding minerals and metals. All information collected is revised before use by the staff with expert knowledge of minerals.

The work done on minerals falls into three branches: Investigations, including analysis and assays, Intelligence and Exhibitions.

Investigations

The investigations on minerals conducted at the Imperial Institute usually arise under four heads:

(*a*) Minerals for which a market is required or concerning which special information is needed are forwarded to the Institute for report by the Mines Departments or other Government Departments in the Dominions, Colonies and India.

(*b*) The Institute directs the attention of overseas Mines Departments to minerals as to which the Imperial Institute has received information that supplies are required in this country or in other parts of the Empire. This leads to the submission of samples for examination and valuation by the Departments consulted.

(*c*) Minerals are received for investigation from special Surveys in overseas countries, whether carried on in association with the Imperial Institute or not.

(*d*) Minerals are forwarded for report by private firms or persons in various parts of the Empire.

The minerals received are first examined by the special staff in the laboratories of the Institute as to composition and quality, so that an estimate of value may be obtained in consultation with manufacturers, merchants, etc. Full reports are forwarded to the Departments and correspondents concerned, with a request for any further information needed, such as extent of the deposit, names of producers, etc. Finally, when information is complete, any necessary action is taken by the Imperial Institute to establish a market for the mineral by putting producers in communication with British buyers, who are supplied with full information respecting the mineral in question. In certain cases the Imperial Institute takes charge of and supervises the sale on Government behalf of trial consignments of minerals. Examples of cases in which the Imperial Institute has arranged a market for minerals are quoted on pp. 341–347.

In the course of each year the Institute receives minerals for examination from nearly every country in the Empire. Thus in 1915 and 1916 minerals were examined from the following countries and reports made: India, Ceylon, Sierra Leone, Gold Coast, Nigeria, Sudan, Somaliland, Uganda, East Africa, Rhodesia, Union of South Africa, Seychelles, Cyprus, Canada, Newfoundland, West Indies, British Guiana, Falkland Islands, Australia, Fiji and New Zealand.

Mineral Surveys.—There are a number of countries, especially among the Crown Colonies and Protectorates, of which the mineral resources are little known. In some of these countries in which there was reason to believe that minerals of economic importance occurred, the Imperial Institute has arranged with the Governments concerned for the necessary explorations to be made by competent geologists, with mining experience, specially

selected for the purpose. These Mineral Surveys have been arranged for terms of years, and being directed from the economic standpoint have been productive of important results.

All minerals found by the Surveyors are forwarded to the Imperial Institute for examination, assay and commercial valuation, and any further explorations of the deposits which prove to be necessary are then arranged to be undertaken by the Surveyors. These surveys were instituted by the Imperial Institute for the express purpose of ascertaining the existence and value of mineral deposits of probable commercial importance. It is not claimed that they serve the same scientific purpose as a Geological Survey, by which in certain cases they might be followed, but that they are most effective for their economic purpose, and it is clear that they might be extended with great advantage to several countries of which the mineral resources are at present not well known.

Intelligence

Published information respecting new occurrences of minerals of economic importance and new developments in their industrial utilisation is collected and arranged on a systematic plan, and the same course is adopted with regard to information periodically received from Departments of Mines and other Government Departments at home and overseas, and also from correspondents throughout the Empire. The Institute receives regularly the publications of Dominion, Colonial and Indian Government Departments concerned with minerals and metals, and as far as possible similar publications issued by Foreign Governments and by the various scientific and technical societies and also the technical and trade journals on these subjects. The whole of the indexed information is used in answering enquiries received at the Institute and in preparing publications and reports on mineral investigations. Illustrations of the results of this intelligence work are given on pp. 350 to 351.

Exhibitions

The Institute maintains Reference Sample Rooms in which are shown samples of all raw materials, including minerals, which have been investigated at the Institute and as to which full information is available as to sources of supply, composition, uses and commercial value. These sample rooms have proved useful in dealing with verbal enquiries from merchants and manufacturers as to new sources of supply of raw materials within the Empire.

In addition to this special exhibition of fully investigated raw materials, the Imperial Institute maintains in its Public Exhibition Galleries a comprehensive exhibition of the chief raw materials, including minerals, of the Empire. This exhibition, which is in charge of a qualified staff, is arranged on a geographical system, all the countries of the Empire being represented. The minerals and mining industries of these countries are well illustrated; thus in the Canadian section there are exhibits of the chief minerals of the Dominion and other exhibits illustrating the uses to which they are applied in industries. For example, various grades of Canadian mica are shown together with specimens of articles manufactured with mica. The same applies to asbestos, nickel, corundum, and other minerals.

Minerals from countries overseas, for which a market is required, are brought to the notice of the Raw Materials Committee (see p. 337), and through it to the Chambers of Commerce throughout the country, and similarly these Chambers through the Committee bring to the notice of the Imperial Institute minerals for which there is a demand in the United Kingdom.

Illustrations of Results of the Work of the Imperial Institute on Minerals

Investigations

Bauxites.—The Empire possesses in India and British Guiana large supplies of this important ore of aluminium which still remain unutilised, chiefly because of their distance from places at which manufacture can be carried on. The Imperial Institute has fully examined in its

laboratories bauxites from the most important deposits in Central India, and has shown that these are suitable for the manufacture of aluminium and aluminium products. It has been in communication with those interested in the development of these deposits and has given advice with regard to all the schemes which have at various times been put forward for their utilisation. These schemes have included the treatment of the bauxite for extraction of aluminium, manufacture of aluminium nitride with a view to the production of ammonia and alumina, use of the ground bauxite as a filtering medium, etc. The Institute has also called the attention of British manufacturers to the important bauxite deposits of British Guiana.

Diatomite.—Before the war this country derived its supplies of diatomite largely from Germany, although this material occurred in the United Kingdom and also in East Africa, Canada and Australia, to mention only a few of the British localities from which material has been examined and reported on by the Imperial Institute. Some years ago a considerable increase in the demand for diatomite arose through its use as a filtering medium. For this purpose diatomite of particularly good quality is required, and it is believed that this special quality was before the war being supplied indirectly from Australia. On the outbreak of war the Imperial Institute was consulted as to possible sources of supply of diatomite of high quality, and from investigations made it seemed clear that the diatomite of Lillicur in Victoria, Australia, would answer the purpose. A trial quantity was obtained through the High Commissioner in London from the Mines Department of Victoria and distributed to possible users in this country. As a result several of these users requested supplies and were placed in communication with the producers. Subsequently the producers were given the names of possible buyers in allied and neutral countries, and it seems likely that a steady export trade in this diatomite from Australia will result as soon as shipping difficulties can be overcome, some consignments having been sold even in the recent difficult circumstances. This investigation also brought to light other sources of supply of diatomite in Australia and

Canada, one of which is suitable for dynamite, for the manufacture of which a first consignment has been purchased by British manufacturers of explosives, through the Imperial Institute.

Corundum.—Owing to the war a considerable amount of interest has been displayed by British firms in securing additional supplies of corundum, which is used as an abrasive. Hitherto supplies have come mostly from Canada, and these have been properly ground and graded before export. There has, therefore, been some difficulty in getting buyers to take the crude lump corundum which can be obtained from other parts of the Empire. The Imperial Institute has, however, been able to put producers of corundum in India in touch with manufacturers in this country, and it is hoped also to obtain supplies from the Federated Malay States. Before the war the corundum produced in the Northern Transvaal was beginning to be exported to Germany, and the war cut off this promising market. The Imperial Institute received samples of this Transvaal corundum, and as on examination it proved to be of fair quality, the producers were recommended to ship a trial consignment for sale in London. This was done and a good price was obtained, with the result that there is now every prospect of an extended market for Transvaal corundum in this country, in addition to the corundum of India, Canada and the Federated Malay States.

Mica.—The Institute has investigated the quality and has reported on mica from Ceylon, Nigeria, Nyasaland, East Africa, India and elsewhere. Two illustrations may be given of effective commercial work in this connection. A deposit of mica of considerable extent has been located recently in Central India through the work of the Imperial Institute. A consignment of this mica was forwarded to the Institute for disposal in London. A report on the quality and grading of this mica was prepared in consultation with experts, and the graded mica was then sold at satisfactory prices. Samples of the grades were returned to the producers in India with instructions for the preparation, grading and packing of the mica for future guidance. The results of this action were satisfactory, and the

Imperial Institute is now drawing up a scheme to assist those concerned in the development of this deposit. Somewhat similar action is now being taken in connection with Ceylon mica, the output of which has been irregular, mainly because the mines are mostly in the hands of natives, who have not been in a position to put their produce directly on the London market. The Imperial Institute is now consulting mica merchants in London with a view to devising a plan whereby this difficulty will be overcome and a regular supply of Ceylon mica assured to this market. One trial consignment of Ceylon mica has already been received, graded and sold at satisfactory prices.

Manganese Ores.—In the course of the last few years the Institute has reported on manganese ores from India, Union of South Africa, East Africa, Gold Coast and elsewhere, chiefly in connection with steel manufacture. Before the war the special manganese ore used for the manufacture of dry electrical batteries was obtained from Germany, and when this source of supply was cut off manufacturers were no longer able to produce satisfactory dry cells, which are used in large quantities for electric bells, telephones, etc. The difficulty was enhanced by the fact that no specification existed for manganese ore for this purpose. The Imperial Institute made enquiries, the results of which made it possible to prepare a provisional specification. Then from the records the Institute possessed of the composition of manganese ores from all parts of the Empire it was possible to put manufacturers in touch with producers of the quality of ore required in Canada and India, and in a short time definite orders for supplies from these localities were given.

Ores for the Manufacture of "Special" Steels.—Prior to the war British steel-makers had relied largely on Germany, France and the United States for supplies of the alloys of titanium, tantalum, tungsten, molybdenum, etc., which are now used in the manufacture of "high speed" and other special steels which are of first-rate importance in modern engineering industries. Nearly all the ores from which these alloys are made are more or less monopolies of the British Empire so far as production is concerned, though

before the war the output went chiefly to foreign countries, where the alloys were made and in part exported to this country. This condition of things has been remedied since the war, and the alloys are now being made here. The Institute had prepared and in some cases published complete records of the occurrence of these ores within the Empire, had made analyses of many of them, and had in fact taken action with the Admiralty to get West Australian tantalite used in this country for steel manufacture before the war. Early in 1915 there was a great shortage of molybdenite in this country, and the Institute took action to increase supplies. A memorandum was prepared stating the quality of ore required in this country, the possible sources of supply within the Empire, the value of the ore, and the chief uses to which it was applied. Copies of this memorandum were sent to all the Mines Departments in those parts of the Empire where molybdenum ores were known to the Institute to be obtainable. A large increase in supplies to this country has now taken place. This action was specially effective in Canada, and in a paper recently published in *National Progress* (Toronto), Mr. C. C. Mackenzie gives an account of the recent important developments of molybdenite production in that Dominion, directly resulting from action taken by the Canadian Mines Department in response to the circular issued by the Imperial Institute.

The Imperial Institute has also been instrumental in placing alloy makers in this country in touch with producers of titanium ores in Australia and India, and of tungsten ores in India and South Africa. It has also recently provided the Admiralty with a detailed statement as to sources of supply of titanium ores within the Empire, and is now revising a map of the mineral resources of the Empire in which these sources of special steel alloys will be given particular attention.

Monazite.—Until a few years ago the sole source of supply of thoria, the principal and essential ingredient in the mantles used for incandescent gas lighting, was monazite from Brazil. The Brazilian deposits were under the control of the German Thorium Syndicate, which was thus

in a position to dictate to the rest of the world the price at which mantles should be sold and where they should be made. Many attempts were made to break this monopoly, and the Imperial Institute has invariably given assistance to British firms who desired to secure independent sources of supply. The discovery of the new mineral thorianite in Ceylon (see p. 349), which proved to be the richest ore of thorium, was made by the Mineral Survey, carried on in co-operation with the Imperial Institute. It provided a new, though small, independent supply, and also gave a great stimulus to the search for thorium minerals. In recent years monazite has been found by the Imperial Institute in sands from Ceylon, Malay Peninsula, Nyasaland, Northern Nigeria and elsewhere in the Empire. The Imperial Institute also made the first analysis published of the monazite from Travancore, which is now the most important source of supply of this mineral in the world. Reference is elsewhere made (p. 349) to the subsequent discovery by the Mineral Survey of beach deposits of monazite sand in Ceylon, which it is hoped will make a useful contribution to British sources of supply of this mineral in the near future.

Apart from the assistance thus given by the discovery of new sources of supply of monazite, the Imperial Institute has also contributed to scientific and technical knowledge of thorianite, monazite and other thorium minerals, and Mr. S. J. Johnstone, B.Sc., of the Imperial Institute Staff, has contributed a number of papers dealing with monazite and other rare earth minerals to technical societies, and is also the author of a well-known work dealing with the industries of the rare earths (*The Rare Earth Industry*: Crosby Lockwood, 1915).

Petroleum.—In 1903, at the request of the Admiralty, the Imperial Institute prepared a memorandum describing the known and prospective sources of supply of petroleum within the Empire. Since that time continuous attention has been given to this important subject, and a large number of samples of crude petroleum, oil-shales, asphalt, etc., have been reported on from British Guiana, Trinidad, Barbados, New Brunswick, Newfoundland, Somaliland,

East Africa, Gold Coast, Nigeria, Australia, Papua, etc. In certain of these cases important developments have since taken place, notably in Trinidad, whilst in others investigations are still in progress, in some instances with considerable promise of success. It cannot be claimed that any source of supply of petroleum of first-class importance has yet been found within the Empire, but sufficient has been done to show that including deposits of oil-shale there is a considerable possibility of further oil production within the Empire.

These illustrations of the work of the Institute in assisting in the utilisation of the mineral resources of the Empire are quoted to show the methods adopted, the great variety of materials which have been dealt with, and incidentally the necessity of a central clearing house for investigations and intelligence regarding minerals, so that the needs of any one part of the Empire may be supplied as expeditiously as possible from the supplies in another part.

Mineral Surveys

Mineral Surveys have been arranged by the Imperial Institute in co-operation with the Governments in the following British countries: Southern Nigeria, Northern Nigeria, Nyasaland and Ceylon.

Imperial Institute Reports on the results of these Mineral Surveys have been published as Parliamentary Papers—for Ceylon (five reports, 1903–10); for Nyasaland (three reports, 1906–9); for Southern Nigeria (ten reports, 1903–13); and for Northern Nigeria (four reports, 1904–9).

These Surveys have been conducted by Officers selected by the Imperial Institute, and have yielded results of economic importance, of which the following illustrations may be quoted:

Southern Nigeria.—The most important result of the Survey in Southern Nigeria was the discovery of a coalfield estimated to be at least 1,800 square miles in extent. An extensive series of samples of the coal was collected and examined at the Imperial Institute. The results showed that the coal was of good quality and suitable for general use, including steam-raising. The extent of the field was

then determined approximately by the Officers of the Survey, who also selected the site at which development should be commenced, and the field is now being worked by the Government of Southern Nigeria. Already a large quantity of coal has been produced, and there seems no doubt that this coalfield will ultimately provide a fuel supply for West Africa and render all that territory independent of imported coal. A description of the work done by the Mineral Survey in connection with this new West African coalfield is given in the article on "The New Coalfield in West Africa" in this BULLETIN (1916, **14**, 369).

In addition to this discovery of coal, the Survey also investigated a large deposit of lignite, or brown coal, in Southern Nigeria, and this also was fully explored and described. The lignite was examined at the Imperial Institute and found to be of good quality and convertible by briquetting into a satisfactory fuel. The Institute investigated various methods of briquetting, and decided on the system best adapted to the purpose, and obtained a full specification of the plant required and the cost. Large-scale briquetting trials were also arranged and a consignment of lignite briquettes sent to Nigeria for firing trials. The investigation was therefore carried by the Imperial Institute up to the stage at which commercial development could begin, but the discovery of the coalfield referred to above deferred further action as to the utilisation of the lignite.

In addition, the Survey in Southern Nigeria has investigated certain occurrences of mineral oil in connection with their commercial development, and has also examined occurrences of ores of lead and zinc, and advised as to their commercial development.

Northern Nigeria.—During the progress of the Mineral Survey of Northern Nigeria important deposits of iron ore were found and examined in the neighbourhood of the River Niger. Samples of these ores were examined at the Imperial Institute and a report prepared for Government. The attention of British ironmasters was then called to these deposits, and much interest was taken in them. The further consideration of the utilisation of these ores is

delayed owing to the war, both as regards their export and their possible use for smelting with the native coal in the country.

The Survey also discovered new tinstone areas in Northern Nigeria, and did much to promote the early development of tin production in that country.

Ceylon.—The work done by the Mineral Survey of Ceylon has included a thorough investigation of the known mineral deposits, and especially of the distribution of plumbago, mica and gemstones, which are the most important minerals produced. In addition, occurrences of other important minerals, such as iron ore and molybdenite, have been recorded. Perhaps the most important work accomplished by the Survey is the investigation of the resources of the island in thorium minerals. Reference has been made (p. 346) to the German Thorium Syndicate's control of supplies of thorium minerals and to the difficulties this control placed in the way of British firms who wished to manufacture thoria. In this connection the discovery by the Mineral Survey of the new mineral, thorianite, was of importance. Thorianite is the richest thorium mineral known, and the first supplies placed on the market were sold through the Imperial Institute to British makers of thorium nitrate at the rate of £1,600 per ton.

The discovery of thorianite in Ceylon gave a great stimulus to the search for thorium minerals, especially in neighbouring countries, and monazite was shortly afterwards found by the Imperial Institute in sands from the Federated Malay States, Nigeria and elsewhere. The continued investigations of the Mineral Survey in Ceylon have resulted in the discovery of beach deposits of monazite sand in that island, and the Government of Ceylon have now made arrangements for working them. The Ceylon sand has been investigated by the Imperial Institute, which has also conducted trials of concentrating machinery, and finally selected plant which has now been shipped to Ceylon for working the sands. The deposits are less extensive than those of Travancore, but they will make an effective contribution to British sources of supply of this important mineral.

Intelligence

The information collected, arranged and indexed, as described on p. 340, is used in connection with the preparation of reports on mineral investigations, full details being given in these reports of the commercial position of the material dealt with where this is necessary. It is also employed in answering the numerous enquiries on minerals received and dealt with each year by the Technical Information Bureau of the Imperial Institute. This information is also employed in the preparation of the special articles on Mineral Resources which are published in this BULLETIN, but which in future, as recommended by the Mineral Resources Committee, will be issued separately.

These articles give a detailed account of the ores of each metal, notes on all the known occurrences of economic importance, particulars of deposits worked, notes of special mining and concentration processes, statistics of production for each country, prices of the ores, notes as to the quality of ore required, and such general information as is available with reference to methods of usage.

The following are the subjects of the principal articles on mineral resources which have been published in this BULLETIN:

Mica (1904).
Diatomite (1905).
Thorium minerals (1905).
Asbestos (1905 and 1908).
Platinum (1906).
Corundum (1906).
Graphite (1906).
Petroleum (1903).
Manganese (1907).
Tantalum (1907).
Molybdenum (1908).
Tungsten (1909).
Vanadium (1909).
Chromium (1910).
Titanium (1911 and 1917).
Bismuth (1912).
Mercury (1913).
Cerium earths (1914).
Tin (1914).
Beryllium (1914).
Zinc (1915 and 1916).
Peat (1905 and 1916).
Nickel (1916).
Queensland sapphires (1916).
Antimony (1916).
Cobalt (1916).

Special attention is given to British sources of supply. Advance copies of these articles are furnished to the chief mining and metallurgical journals for review, and the attention of all merchants and manufacturers known to be interested is also called to them.

A separate publication relating to the "World's Supply

of Potash" was issued soon after the outbreak of war, when the Imperial Institute received a very large number of enquiries as to sources of supply of potash. The first edition of this pamphlet was exhausted soon after its issue and a second edition is being prepared. Similar publications on the ores of zinc, manganese, tin and other metals are now in preparation.

The information on mineral resources thus systematically collected and indexed at the Imperial Institute has also been used for other important purposes, and especially in the last three years in answering enquiries as to ores made by the Admiralty, Ministry of Munitions and other Departments directly concerned with the war.

The Institute has prepared for the War Trade Advisory Committee a map showing the principal petroleum resources of the Empire, and is now revising for the same Committee a map showing the distribution within the Empire of mineral deposits of economic importance. The Institute has also compiled for the War Trade Intelligence Department a statistical and technical statement on the production and utilisation of certain metals and minerals in Germany before the war, and has been largely consulted by the Treasury, War Trade Department, War Trade Intelligence Department, and by other Departments concerned with the questions involved in dealing with contraband trade in minerals and metals and the issue of licences for the export of such materials.

Co-operation with Overseas Departments

The Institute is in communication with the Departments of Mines and Geological Surveys in the Dominions (the communication being either direct or through the High Commissioners and Agents-General in London), the Colonies and India, and with the appropriate Departments in those Colonies and Protectorates in which there is no separate Mines Department. From these Departments, the Institute receives publications respecting minerals and mines, with such statistics of production and output as are issued. The Institute also applies to these Departments for any special information that may be required,

and as already indicated receives from these Departments minerals for examination and report, and enquiries for special information.

The following is a list of the principal Departments in the Dominions, Colonies and India with which the Institute is in communication:

Commonwealth of Australia:	
New South Wales	Department of Mines.
Queensland	Department of Mines.
South Australia	Mines Department.
Tasmania	Mines Branch of the Lands and Works Department.
Victoria	Department of Mines.
Western Australia	Department of Mines.
Dominion of Canada:	
Dominion Department	Department of Mines.
Ontario	Department of Mines.
Newfoundland	Department of Agriculture and Mines.
New Zealand	Department of Mines.
Union of South Africa	Department of Mines and Industries.
East Africa Protectorate	Commissioner of Mines.
Rhodesia	Department of Mines and Public Works.
India	Geological Surveys.
Ceylon	Mineral Survey.
Federated Malay States and Straits Settlements	Government Geologist.
Gold Coast	Geological Survey.
Uganda	Commissioner of Mines.

The Imperial Institute is also in communication respecting minerals with various Departments of the following Governments:

Bahamas.
Barbados.
British Guiana.
British Honduras.
Cyprus.
Egypt.
Falkland Islands.
Fiji.
Gambia.
Grenada.
Jamaica.
Leeward Islands.
Nigeria.
Nyasaland.
Seychelles.
Sierra Leone.
Somaliland.
Sudan.
Trinidad.
Zanzibar.

Co-operation with Technical and Scientific Societies concerned with Minerals and Metals

There are within the Empire a considerable number of scientific and technical societies concerned in the publication of papers bearing on the mineral resources of the

Empire. The Imperial Institute exchanges publications with these societies, and indexes and publishes in its Bulletin abstracts of the more important papers.

The Imperial Institute also prepared for the International Geological Congresses held at Stockholm and Toronto monographs on (1) The Iron Ore Resources of the British Crown Colonies and Protectorates, and (2) The Coal Resources of the British Crown Colonies and Protectorates, which were published in the General Reports issued by these Congresses on the Iron Ore and Coal Resources of the World.

Members of the staff of the Imperial Institute have contributed numerous papers to the British scientific and technical societies concerned with mineral investigations, have served on the councils of some of these societies, and have taken part in the discussions which these societies have arranged in recent years on various aspects of mineral investigation, one of the most recent examples being a discussion on refractory materials at the Faraday Society.

GENERAL ARTICLES

INDIAN TRADE IN OIL SEEDS

No country in the world produces such a variety of oil seeds in commercial quantities as India. West Africa has probably a greater variety of this class of raw materials, but of these only two, palm kernels and ground nuts, are of great commercial importance.

The great value of India's trade in oil seeds is not generally realised, in spite of the fact that the production in India is probably well over 5,000,000 tons in quantity and £50,000,000 in value per annum. The exports of oil seeds from India in 1913–14 amounted to nearly 1,600,000 tons, valued at approximately £17,000,000. To this there must be added an export of about 3,250,000 gallons of oil valued at nearly £400,000, and an export of nearly 200,000 tons of oil-cake worth about £1,000,000.

The annual value of the export trade of India in oil seeds and their products may therefore be placed at about £18,500,000, taking 1913–14 as an average year.

According to the official Indian Trade Returns, about one-third by weight of the oil seeds exported from India in 1913–14 was sent to the United Kingdom, but only a little more than one-fifth by value, the principal items in the United Kingdom imports being the relatively cheap seeds, linseed and cotton seed. About one-quarter by weight of the exports in the same year, but about one-third by value, went to France, the chief items exported to France being ground nuts and linseed. Germany's share of the exports in the same year amounted to about one-eighth by weight, but about one-sixth by value, the chief items being the relatively valuable seeds, copra, mowra and sesame, followed by rape seed and linseed. The other countries which in 1913-14 shared to a considerable extent in India's exports of oil seeds were Belgium (chiefly linseed and rape seed), Italy (largely linseed and sesame seed), and Austria-Hungary (chiefly sesame and ground nuts). Between them these six countries absorbed 1,500,000 tons out of the 1,600,000 tons of oil seeds exported from India in that year, and the first four divided among them no less than 1,380,000 tons.

At first sight it would appear that if the United Kingdom were able to take about one-third of India's output of oil seeds in 1913–14, whilst France took one-quarter and Germany one-eighth, the position was not unsatisfactory from the point of view of the development of inter-Imperial trade. But careful comparison of the position of the oil-seed crushing industry in the United Kingdom and in the more important oil-seed crushing Continental countries shows that the position is not so satisfactory as appears on the surface, either from the point of view of the Indian oil-seed producer or the British oil-seed crusher.

It has been considered desirable therefore to publish in this Bulletin a comprehensive statement on the Indian oil-seed trade, with the twofold object of calling attention to its great importance, and of emphasising the desirability of securing that a far larger proportion of India's output

of oil seeds shall be utilised in the Empire than has been the case in the past. No attempt can be made in this BULLETIN to suggest what steps, if any, should be taken to secure the latter object, and all that can be done is to call attention to the present position, or rather to the position as it was in 1913–14. In some respects it has altered to the advantage of this country since the outbreak of war, but it can hardly be assumed that this will be a permanent alteration if conditions after the war resemble those obtaining in 1913–14.

The article is divided into two sections—General and Special—the former dealing with the trade in general and the latter with the individual oil seeds of which the trade composed.

GENERAL SECTION

OIL SEEDS EXPORTED FROM INDIA

The principal oil seeds grown in and exported from India are as follows:

Copra.	Linseed.	Rape.
Ground nuts.	Sesame.	Cotton.
Mowra.	Castor.	Niger.
Poppy.		

These may be classified according to the character of the oil they yield as follows:

1. *Solid Fats.*—Copra, mowra.
2. *Non-drying Oils.*—Ground nut, castor.
3. *Semi-drying Oils.*—Cotton seed, rape, sesame.
4. *Drying Oils.*—Linseed, poppy seed, niger seed.

A better classification from the manufacturers' point of view is that of the amount of oil obtained from the seeds, since this determines to some extent the type of machinery required to deal with them. On this basis they may be grouped as follows:

Group 1 (13 to 36 per cent. of oil or fat).—Cotton, linseed, niger, rape.

Group 2 (42 to 65 per cent. of oil or fat).—Poppy, ground nut, sesame, castor, mowra, copra.

General Character of the British Oil-seed Crushing Industry

Speaking generally, British oil-seed crushers have devoted attention mainly to the treatment of seeds belonging to group 1, that is, seeds giving a comparatively low yield of oil and a large yield of oil-cake. Most British oil-seed crushing mills are still equipped with machinery for dealing with this group of seeds, though in recent years, and especially since the outbreak of war, the condition of things has been modified to some extent, and increasing quantities of the richer oil seeds, such as copra, palm kernels and ground nuts, are being crushed or extracted in this country. Much, however, still remains to be done in this direction. The reason for the backward condition of the British oil-seed crushing industry, taken as a whole, is mainly that it began in the days when oil-cake for feeding cattle was the chief desideratum and the oil a relatively unimportant material, and this has largely determined the kind of seed crushed. The demand for oils for the manufacture of margarine and other edible fats arose on the Continent and expanded there far more rapidly than in this country, and with its expansion grew up the modern Continental, and especially German, oil-seed crushing and extracting industry, the chief object of which was to produce edible oils and fats. The German oil-seed crushers, therefore, gave special attention to copra, palm kernels, mowra seed and other seeds rich in oil. Further, they began later than their British competitors and therefore had the advantage of later equipment and plant, and more modern arrangement of factories. In recent years the German oil-seed crushers have not only monopolised to a large extent the crushing of the rich oil seeds, but they have also made serious inroads into the crushing of cotton seed, which, so far as Europe is concerned, had been until the last few years practically a British monopoly. Similarly they have entered largely into the production of oil and cake from Manchurian soya beans—an industry which, so far as Europe is concerned, owes its existence to the enterprise of oil-seed crushers in Hull.

Statistics of India's Trade in Oil Seeds, Oils and Oil-cakes

1. *Oil Seeds*

The following tables show (1) the crop yields and total exports for the year 1913–14 (as far as information is available) of the various descriptions of oil seeds grown in India, and (2) the distribution of the exports:

Description of seed.	Crop yield.	Exports. Quantity.	Exports. Value.
	Tons.	*Tons.*	£
Ground nut	749,000	278,000	3,254,000
Linseed	386,000	414,000	4,460,000
Rape	1,087,000 (Rape and Mustard)	249,000	2,850,000
Mustard		5,000	70,000
Sesame	503,000	112,000	1,800,000
Cotton	2,120,000	284,000	1,417,000
Castor	Figures not available	135,000	1,337,000
Copra	" " "	38,000	1,040,000
Mowra	" " "	33,000	364,000
Poppy	30,000	19,000	311,000
Niger	Figures not available	4,000	43,000
Total	—	1,571,000	16,946,000

Destinations of Exports (Principal Countries)

Description of seed.	United Kingdom.	France.	Belgium.[1]	Italy.	Germany.	Austria-Hungary.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Ground nut	500	222,400	16,600	1,200	9,400	10,700
Linseed	157,300	115,500	38,500	30,700	48,300	6,500
Mustard	900	2,400	1,000	—	300	—
Rape	14,100	53,900	98,900	13,700	58,200	5,500
Sesame	—	22,200	33,800	14,300	16,500	19,300
Cotton	279,200	2,300	—	—	500	—
Castor	55,700	21,000	14,800	11,800	9,800	—
Copra	300	3,400	5,000	—	24,000	500
Mowra	—	400	4,400	—	28,400	—
Poppy	—	10,700	4,800	—	3,300	—
Niger	370	1,050	20	50	2,030	570
Total	508,270	455,250	217,820	71,750	200,730	43,070

[1] *In part re-exported to enemy countries.*

2. *Oils*

The destinations of India's exports of vegetable oils are many and various. The following tables show the

principal destinations of the exports of the various oils in 1913–14:

Castor oil. To	Gallons.	Coconut oil. To	Gallons.	Linseed oil. To	Gallons.
United Kingdom	87,256	United Kingdom	223,756	United Kingdom	6,636
Ceylon	73,730	Natal	13,262	Hong Kong	22,740
Straits Settlements	141,414	Sweden	119,541	Australia	18,355
Natal	47,925	Germany	161,632	New Zealand	28,330
Mauritius	92,050	Holland	29,283	Germany	3,576
Australia	360,252	Belgium	43,571	Philippines	8,506
New Zealand	146,659	U.S.A.	447,664	Japan	5,509
Siam	16,273	Other countries	52,768	Other countries	8,708
Portuguese East Africa	8,365				
Other countries	33,077				
Total	1,007,001	Total	1,091,477	Total	102,360
Value	£92,504	Value	£155,073	Value	£17,493

Ground-nut oil. To	Gallons.	Mustard and rape oils. To	Gallons.	Sesame oil. To	Gallons.
Ceylon	159,232	United Kingdom	8,580	Aden	35,647
Mauritius	107,308	Natal	94,916	Ceylon	31,609
France	11,241	Mauritius	189,651	Maskat	63,510
Other countries	10,409	British Guiana	31,267	German East Africa	10,443
		Fiji	41,329	Other countries	66,844
		Other countries	41,435		
Total	288,190	Total	407,178	Total	208,053
Value	£30,013	Value	£48,624	Value	£28,699

Niger-seed Oil—None in 1913–14

Other Vegetable Oils.

To	Gallons.
United Kingdom	7,987
Ceylon	14,418
Germany	57,475
Holland	7,897
Belgium	39,235
Other countries	8,309
Total	135,321
Value	£12,900

Grand total of exports of oils: Gallons, 3,242,807. Value, £385,653.

3. *Oil-cakes*

The following table shows the exports of oil-cakes from India in 1913-14 and their chief destinations:

Description of cake.	United Kingdom. *Tons.*	Ceylon. *Tons.*	Germany. *Tons.*	Japan. *Tons.*	Total. *Tons.*
Castor cake	—	4,902	—	—	4,902
Coconut cake	125	—	4,066	—	4,208
Cotton-seed cake	8,955	5	1,469	—	10,428
Ground-nut cake	32,720	14,967	12,167	—	62,026
Linseed, rape and sesame cakes	18,198	24,683	1,207	45,284	89,488
Others	282	2,330	—	1,086	4,259
Total	60,280	46,887	18,909	46,370	175,311

The data recorded in the foregoing tables may be conveniently summarised as follows :

Indian Oil Seeds, Oil-cakes and Oils. Export Statistics for the Year 1913–14

Description.		Total exports.	Exported to United Kingdom.	France.	Belgium.	Italy.	Germany.	Austria-Hungary.
Ground nuts	*tons*	278,000[1]	500	222,400	6,640[2]	1,200	19,360[3]	10,700
Ground-nut cake	,,	62,026	32,720	—	—	—	12,167	—
,, oil	*galls.*	288,190	—	11,241	—	—	—	—
Linseed	*tons*	414,000	157,300	115,500	23,100[2]	30,700	63,700[3]	6,500
,, oil	*galls.*	102,360	6,636	—	—	—	3,576	—
Rape seed	*tons*	249,000	14,100	53,900	54,900[2]	13,700	102,200[3]	5,500
Mustard seed	,,	5,104	900	2,384	1,029	—	328	4
Rape and mustard oil,	*galls.*	407,178	8,580	—	—	—	—	—
Sesame seed	*tons*	112,000	—	22,200	17,800[2]	14,300	32,500[3]	19,300
,, oil	*galls.*	208,000	4,000	—	—	—	—	—
Linseed, rape and sesame cakes	*tons*	89,500	18,198	—	—	—	1,207	—
Cotton seed	,,	284,000	279,200	2,300	—	—	500	—
,, ,, cake	,,	10,428	8,955	—	—	—	1,469	—
,, ,, oil	*galls.*	2,500	—	—	—	—	—	—
Castor seed	*tons*	135,000	55,700	21,000	14,800	11,800	9,800	—
,, cake	,,	4,902	—	—	—	—	—	—
,, oil	*galls.*	1,007,000	87,256	—	—	—	—	—
Copra	*tons*	38,000	300	3,400	4,000[2]	—	25,000[3]	500
,, cake	,,	4,208	125	—	—	—	4,066	—
,, oil	*galls.*	1,091,500	223,756	—	43,571	—	161,632	—
Mowra seed	*tons*	33,000	—	400	4,400	—	28,400	—
Niger seed	,,	4,107	367	1,046	20	50	2,029	566
Poppy seed	,,	19,000	—	10,700	4,800	—	3,300	—
Tea seed	,,	392	65	—	—	—	—	—
Other oil seeds (non-essential)	*tons*	516	379	35	20	—	12	14
Other oil-cakes	,,	4,259	282	—	—	—	50	—
Other oils	*galls.*	135,321	7,987	—	39,235	—	57,475	—

[1] *Exclusive of* 105,500 *tons, largely the produce of British India, exported from French Possessions in India* (86,500 *tons from Pondicherry*). *Most of these exports went to Marseilles.*

[2] *Corrected for re-exports to Germany.* [3] *Includes imports from Belgium.*

The following points regarding the more important oil seeds included in the foregoing tables may be noted:

Ground Nut.—Much more than half the crop was retained; the oil is largely consumed in India, and the cake is used as a manure for high-priced crops. It is also used by the tea planters of Ceylon and Southern India for the same purpose. The value of the oil and cake exported was about £300,000.

In the last few years a ground-nut crushing industry has begun to develop in Burma.

Linseed.—Practically the whole of the crop is exported.

India imported 438,000 gallons of linseed oil from the United Kingdom in 1913–14.

The export of linseed in 1913–14 was larger than the yield recorded for that year. This was due to the fact that the yield for that year was considerably below the average, and the exports during the year comprised a portion of the previous year's crop. The average yield for the three years 1911–12 to 1913-14 was 520,000 tons, whilst the average export was 430,000 tons.

Rape, Mustard and Sesame.—About one-quarter of each of these crops was exported. The value of the oils and cakes exported was over £600,000. The seeds are largely crushed in India for their oils.

Cotton.—The quantity exported was equal to 15 per cent. of the estimated yield for 1913. The seed is largely crushed locally for its oil and cake. In the Punjab, however, the whole of the local yield of the seed, as well as seed obtained from other parts of India, estimated altogether at 225,000 tons, is used as food for milch cows. The value of cotton cake exported from India was about £50,000, of which Burma contributed more than half, although her share of the cotton-seed crop of India was about 1 per cent.

Castor.—About 1,000,000 gallons of oil valued at £100,000 were exported, principally to countries within the Empire. The seed is crushed locally for the oil and cake. The cake has been used in Northern India as a manure for tea.

Copra.—The value of coconut oil and cake exported was £180,000. A very large quantity of oil and cake is produced and consumed in India.

Poppy.—Probably the bulk of the crop was exported.

An immense quantity of oil is manufactured in India by crude processes. Most of the oil is expressed by pestle and mortar mills worked by bullocks and by hand presses, which exist in all parts of the country, and supply largely the local demand for oils. Within recent years oil mills, fitted with modern machinery and worked by steam or other mechanical power, have been set up in various parts of the country (cf. below); but, in spite of the good local demand for edible oils, many of the attempts to establish mills on a large scale have failed. This is attributed to the want of technical and commercial knowledge on the part of the management, and failure to recognise the necessity for erecting only the best and most modern machinery and of securing efficient scientific control. In Burma especially the oil-crushing industry is, however, now being developed on sound lines by leading European firms, and considerable quantities of ground-nut cake are being exported to the United Kingdom; in 1915–16 for the first time shipments of ground-nut oil were made from Burma. Burma has the advantage of the experience gained by a long-established rice-milling industry, which is largely in the hands of British firms. Many of the Chinese and Indian rice millers in Burma are men of considerable intelligence and enterprise, and might be able to manage oil mills successfully.

Much discussion has taken place in India regarding the desirability of continuing to export large quantities of oil seeds instead of crushing them in the country and exporting the oil and cake, or selling these products locally. The usual arguments in favour of encouraging oil-seed crushing in India are:

(1) That the profits of the industry would be secured for India;

(2) That the cakes would be largely retained in India to be used as feeding-stuffs and manures, and would thus be of advantage to Indian agriculture;

(3) That India, in starting an oil-seed crushing industry, would be competing mainly with industries established in foreign countries; and

(4) That by crushing the fresh oil seeds in India better

oils could be produced than are now obtained from stale oil seeds in Europe.

The arguments on the other side as usually stated may be summarised thus:

(1) That the quantity of oil seeds exported forms a relatively small proportion of the oil seeds produced, and that the first consideration should be to use economically and to the best advantage, which is not the case now, the large quantities of oil seeds retained and used in India.

(2) That India is pre-eminently an agricultural country, and there is no reason why it should not, like Java, develop on agricultural lines. The yield per acre of practically every crop grown in India could be increased, and it would be far sounder economically to give attention to the development of agriculture with a view to increased exports of raw materials than to attempt to start new industries.

(3) That the profits accruing to India from an increased output and an improvement in the quality of oil-seed crops would be greater than she could get at this stage by developing oil-producing industries, and the profits would be shared among a greater number of people.

(4) India already exports some oil and cake, indicating that her actual requirements of these articles are adequately met. It is well known also that the people are unable or unwilling to buy cake to any large extent, and that if under present circumstances oil-seed crushing on a large scale were developed in India, most of the cake and oil would have to be exported. Consequently Indian agriculture would not benefit to any great extent.

(5) It is highly improbable that India could produce for many years to come refined oils of the kind required in Europe, and the oil made would probably have to be refined in Europe.

SPECIAL SECTION

As already indicated, this section of the article will be devoted to considering separately the various oil seeds included in Indian trade. No attempt has been made to achieve uniformity of treatment, especially on technical points. In all cases attention has been concentrated on

the points about which information seems most to be needed in the interests of the development of Indian trade, particularly within the British Empire.

Cotton Seed

The world's production of cotton seed in 1913–14 may be taken to be about 11,000,000 tons, made up as follows:

	Tons.		Tons.
United States	5,620,000	Egypt	620,000
India	2,120,000	Russia	440,000
China	1,600,000	Other countries	600,000

On this basis India produces about 20 per cent. of the world's supply of cotton seed. Of the cotton seed produced in these countries, much is either used locally or is exported in the form of manufactured products. The following, for example, are the exports of cotton seed and cotton-seed products from the United States in 1914–15:

Exports.	Quantity. Tons.	Value. £
Cotton seed	2,819	18,847
" " oil	142,128	4,374,590
" " cake	545,848	3,086,425
" " meal	114,449	694,849

In India and Egypt, as the following figures show, the exports of cotton seed are far larger than those of cotton-seed products; but in the case of India the total exports form only a small part of the total production:

Exports from India, 1914–15

Exports.	Quantity. Tons.	Value. £
Cotton seed	207,789	1,004,524
" " oil	52	1,059
" " cake	6,854	31,660

Exports from Egypt, 1915

Exports.	Quantity. Tons.	Value. £
Cotton seed	360,000	2,410,496
" " oil	4,262	79,472
" " cake	111,668	508,511

India and Egypt, and especially the latter, are the chief sources of supply of cotton seed to those countries which produce none.

The following table shows the world's export trade in cotton seed in the last year before the outbreak of war:

World's Export Trade in Cotton Seed

Exporting country.	Exports. Quantity. Tons.	Value. £	Remarks.
Egypt (1913)	428,136	3,377,375	221,113 tons (52 per cent.) to United Kingdom; 191,900 tons (45 per cent.) to Germany. In 1912 and earlier years there was a much bigger difference between exports to United Kingdom and Germany, in favour of United Kingdom.
India (1913–14)	284,327	1,416,743	279,198 tons to United Kingdom.
British East Africa, chiefly Uganda (1913–14)	9,019	34,684	8,694 " " "
Nigeria (1913)	5,887	14,332	
Sudan (1913)	4,709	21,624	4,396 " " "
Nyasaland (1913–14)	86	329	
St. Vincent (1913)	524	3,065	Mainly to Barbados.
Grenada (1913)	506	2,779	Two-thirds to United Kingdom, one-third to Barbados.
St. Kitts (1913)	206	1,339	Mainly to Barbados.
Exports from British Empire	733,359	4,872,269	
United States (1913–14)	7,295	43,023	6,159 tons to Germany.
China (1913)	10,863	33,584	10,829 " Japan.
Brazil (1913)	47,629[1]	—	United Kingdom imports only. These account for the bulk of Brazil's exports of cotton seed. According to the latest Brazilian returns, these exports in 1912 totalled 36,204 tons, of which 33,481 tons were consigned to the United Kingdom. Probably in the case of the following countries also the bulk of the exports of cotton seed are taken by the United Kingdom.
Turkey (1913)	26,639[1]	—	United Kingdom imports.
Russia (1913)	17,770[1]	—	" " "
Peru (1913)	12,745[1]	—	" " "
Hayti and S. Domingo (1913)	1,992[1]	—	" " "
Exports from foreign countries	124,933	—	

[1] *Part only.*

Though the above table is unavoidably incomplete, it may be estimated that probably under 900,000 tons of cotton seed entered into foreign trade in 1913–14, *i.e.* only about one-twelfth (8 per cent.) of the world's production. The chief consuming country was the United Kingdom, which took about two-thirds of the total exports, the remainder going mostly to Germany.

Of the world's exportable surplus of cotton seed, as distinct from cotton-seed manufactures, the British Empire produces about 80 per cent. and India about 33 per cent.

Trade in Cotton-seed Oil

The figures in the following tables of world trade in cotton-seed oil are extracted from the *Year Book* of the United States Department of Agriculture. "The exports given are domestic exports, and the imports given are imports for consumption as far as it is feasible and consistent so to express the facts":

Exports

Country.	1911. 1,000 galls.	1912. 1,000 galls.	1913. 1,000 galls.
United States of America	43,004	47,457	35,304
United Kingdom	6,782	6,099	7,626
Belgium	1,042	1,341	1,014
Egypt	488	359	619
France	177	172	271
Netherlands	43	40	31
Others	6	40	59
Total[1]	51,542	55,508	44,924

[1] *This does not include exports from China, which have increased rapidly in the last few years. Converting these Chinese exports into gallons (at 9·2 lb. = a gallon), for comparison with the above, the figures are:*

1912 . 183,000 *galls.* 1913 . 964,000 *galls.* 1914 . 1,842,000 *galls.*

In normal years China exports cotton-seed oil chiefly to the United Kingdom and Turkey.

Imports

Country.	1911. 1,000 galls.	1912. 1,000 galls.	1913. 1,000 galls.
United Kingdom	7,361	7,587	4,990
Canada	1,830	2,911	4,104
Malta	261	261	278
Egypt	186	345	118
Australia	119	182	175
Total British	9,757	11,286	9,665
Italy	3,599	5,388	3,957
France	2,609	3,697	2,604
Belgium	2,337	2,876	2,005
Serbia [1]	396	396	396
Senegal	464	382	382 [2]
Martinique	275	262	262 [2]
Algeria	128	118	118 [2]
Roumania	805	593	593 [2]
Germany	6,391	7,900	4,786
Austria-Hungary	15	127	16
Netherlands	3,544	7,048	7,765
Mexico	673	4,310	4,310
Norway	1,492	1,554	1,542
Sweden	680	865	702
Brazil [3]	670	670	440
Uruguay [4]	383	383	383
Others	4,146	4,306	6,466
Total	38,364	52,161	46,392

[1] *Figures for* 1911.
[2] *Figures for preceding year.*
[3] *Figures for* 1909 *in first two columns.*
[4] *Figures for* 1910.

It will be seen that in 1912 three countries—the United Kingdom, Germany and the Netherlands—shared almost equally over 40 per cent. of the supplies of cotton-seed oil entering into foreign trade, each taking between 7,000,000 and 8,000,000 gallons; while another 40 per cent. was shared by Italy, Mexico, France, Canada, Belgium and Norway, whose imports ranged from between 5,000,000 and 6,000,000 gallons (Italy) down to 1,500,000 gallons (Norway).

Of the exports shown in the table on page 365 the United States furnished about 80 per cent. and the United Kingdom about 14 per cent., the United Kingdom exports of home produce being about equal to the imports of foreign produce. The rise of China among exporting countries is of special interest. Already she would seem to take third place. A more detailed statement of the exports from the United States and the United Kingdom, based on their respective trade returns, is given below.

In 1913–14 the exports of cotton-seed oil from the United States were 86,144 tons valued at £2,768,636. The distribution of these exports is very widespread, the chief receiving countries before the war being the Netherlands, Italy, United Kingdom, Canada, Mexico, Argentina, France and Germany. The exports in 1913–14 were exceptionally small. Following are the figures for 1912–13, 1913–14 and 1914–15:

United States Exports of Cotton-seed Oil

	1912–13.		1913–14.		1914–15.	
	Tons.	*Per cent.*	*Tons.*	*Per cent.*	*Tons.*	*Per cent.*
Netherlands	34,300	24	12,100	14	40,600	29
Italy	17,600	12·5	6,300	7·5	7,100	5
United Kingdom	14,200	10	13,900	16	33,200	23·5
Canada	11,300	8	11,400	13	9,200	6·5
Mexico	10,600	7·5	2,800	3	2,100	1·5
Argentina	6,600	5	6,700	8	7,700	5·5
France	8,000	6	3,700	4·5	3,800	2·5
Germany	5,300	4	3,400	4	30	—
Norway	4,000	3	3,100	3	11,800	8
Denmark	1,200	1	900	1	5,900	4
Total ten countries	113,100	81	64,300	74	121,430	85·5
Total all countries	140,700	100	86,100	100	142,100	100

It will be seen that in 1912–13 and 1913-14 the United Kingdom, the Netherlands, Italy and Canada took fully half the total; in 1914–15 the United Kingdom and the Netherlands alone took over half the total, and there were large increases in the exports to Norway and Denmark in that year.

The exports of refined cotton-seed oil from the United Kingdom, classed among home produce and manufactures, in 1913, 1914 and 1915 were as follows:

United Kingdom Exports of Cotton-seed Oil

	1913.		1914.		1915.	
To	*Tons.*	*Per cent.*	*Tons.*	*Per cent.*	*Tons.*	*Per cent.*
Netherlands	7,538	30	14,662	54·5	14,865	69
Belgium	3,251	13	2,244	8	—	—
France	3,214	13	974	3·5	1,527	7
French West Africa	1,562	6	1,855	7	1,155	5·5
United States	2,151	8·5	540	2	5	—
Germany	1,994	8	767	3	—	—
Turkey	1,128	4·5	502	2	45[1]	—
Other countries	4,175	17	5,518	20	3,908	18·5
Total quantity	25,013	100	27,062	100	21,505	100
Total value	£755,083	—	£864,037	—	£677,909	—

[1] *Exported to ports or places in territory formerly Turkish, but now occupied by other Powers.*

In 1916 the exports of refined cotton-seed oil produced in the United Kingdom dropped to 2,407 tons, valued at £101,197, of which 16·5 per cent. went to the Netherlands, 30 per cent. to France, 12·5 per cent. to French West Africa and 41 per cent. to other countries (including 24·5 per cent. to British Possessions).

There is, as a rule, only a small export of unrefined cotton-seed oil from the United Kingdom, as is indicated in the following table. Most of the exports in the exceptional year 1915 went to the Netherlands:

	Quantity. Tons.	Value. £
1913	522	15,453
1914	438	13,198
1915	4,702	127,208
1916	170	6,289

Trade in Cotton-seed Cake and Meal

The following table shows the exports of cake from the chief producing countries so far as figures are available:

Country.	Exports. Quantity. Tons.	Exports. Value. £	Remarks.
United States [1] (1913–14)	357,131	2,201,488	90 per cent. to Denmark, Germany and United Kingdom, viz. to Denmark, 155,171 tons (43 per cent.); to Germany, 107,299 tons (30 per cent.); to United Kingdom, 58,613 tons (16 per cent.). In the two previous years, total exports were about 50 per cent. higher, the above three countries still taking the bulk of the supply.
Egypt (1913)	62,870 [2]	303,191 [2]	62,530 tons to United Kingdom. The exports were much smaller than usual in 1913. Both in 1912 and in 1914 the quantity was nearly 30 per cent. higher.
Russia (1912)	86,000 (part only)	—	Russia's estimated export to Germany (50,000 tons) and Denmark (36,000 tons). See U.S.A. Special Agents' Series, No. 84, pp. 25, 79.

[1] *In* 1914–15 *the figures for cake and meal were given separately, and in that year the exports of cake were nearly four times as large as the exports of meal.*

[2] *Exports of "tourteaux" ("oil-cakes"). As previously noted, practically all these exports go to the United Kingdom, and as the Egyptian figures for exports of "tourteaux" to the United Kingdom are very little in excess of the United Kingdom figures for imports of cotton-seed cake from Egypt, there can be little error in regarding "tourteaux" as practically equivalent in this instance to cotton-seed cake.*

Country.	Exports. Quantity. Tons.	Value. £	Remarks.
Germany (1913)	71,040 (part only)	—	Germany's export to United Kingdom alone, according to United Kingdom trade returns. The German trade returns do not distinguish between the different kinds of oil-cake exported. In 1912 when United Kingdom imports of cotton-seed cake from Germany were 70,617 tons, Germany's production was 160,000 tons, little of it being for home consumption (U.S.A. Special Agents' Series, No. 84, p. 26).
China (1914) .	33,544 (part only)	86,000	Exports from Shanghai, comprising most of the exports of cotton-seed cake from China. Mostly sent to Japan.
India (1913–14)	10,429	48,157	8,955 tons to United Kingdom.
United Kingdom (1913)	7,762	36,638	Practically all to foreign countries, chiefly France and Denmark.

Principal Importing Countries for Cotton Seed and Cotton-seed Products

The average annual imports of cotton seed, cotton-seed oil, and cotton-seed cake and meal into the chief importing countries in the four years 1910–13 were as follows:

Country.	Cotton seed. Tons.	Oil. Tons.	Cake and meal. Tons.
United Kingdom . .	633,145	21,952	218,729
Germany	173,978	18,850	n.s.m.
France	28,187	11,026	,,
Austria-Hungary . .	5,832	270	,,
Netherlands . . .	n.s.m.	23,000 [1]	29,087 [2]
Italy	,,	15,895 [3]	n.s.m.
Denmark	,,	3,221	197,043

n.s.m. = not separately mentioned in the Trade Statistics.

[1] *According to United States Department of Agriculture. According to the Netherlands Trade Returns the average of* 1913, 1914 *and* 1915 *was much less.*

[2] *Average of* 1912–13. *Large quantities of cake and meal are re-exported from the Netherlands.* [3] *Average of* 1911–13.

It is clear from these figures that so far as countries which do not themselves produce cotton seed are concerned, the United Kingdom and Germany were before the war the only countries which possessed a large cotton-seed crushing industry, and that although Germany's cotton-

seed imports were increasing they were still far below those of the United Kingdom. Further, the United Kingdom takes practically the whole of India's output of cotton seed, and also the greater part of the cotton-seed oil and cake exported from India. It should be borne in mind, however, that the United Kingdom may not continue to take so much Indian cotton seed if after the war she is able to buy Egyptian seed on more advantageous terms than Germany. Up to 1905 the United Kingdom took practically the whole of the cotton seed produced in Egypt, but in that year the competition of Germany as a buyer began to be felt, and purchases by Germany increased fairly steadily up to the outbreak of war, as the following table shows:

Exports of Cotton Seed from Egypt

Year.	Total.	To United Kingdom.	To Germany.
	Tons.	*Per cent.*	*Per cent.*
1900	391,233	92·3	n.s.m.
1905	413,794	94·4	0·08
1910	317,516	66·0	28·9
1911	453,432	66·1	29·9
1912	582,748	57·5	37·2
1913	428,136	51·6	44·8
1914	338,757	72·5	24·0
1915	359,981	99·2	nil.
1916	215,348	99·7	nil.

n.s.m. = not separately mentioned.

It was probably this competition for Egyptian cotton seed which led British oil-seed crushers to turn their attention to Indian cotton seed, which began to be exported in quantity about 1900.

Exports of Cotton Seed from India

Year.	Total.	To United Kingdom.	
	Cwts.	*Cwts.*	*Per cent.*
1894–5	96,769	74,716	77
1900–01	224,901	138,506	62
1901–2	2,036,056	1,693,811	83
1905–6	3,891,339	3,476,848	89
1910–11	5,980,226	5,803,091	97
1914–15	4,155,778	4,048,818	97
1915–16	1,913,273	1,865,326	98
1916–17	792,608	748,675	94

Quality of Indian Cotton Seed compared with Egyptian

Indian cotton seed is inferior to Egyptian seed and realises from £2 to £3 per ton less in the market. This is mainly due to the fact that it is a "fuzzy" instead of a "smooth" cotton seed and therefore yields an inferior feeding-cake, unless it is delinted and then hulled to produce decorticated cake, which is not the practice in the United Kingdom. Further, it yields only about 13 per cent. of oil as compared with 16 to 17 from Egyptian seed, and the oil is more troublesome to refine, though this difficulty is said now to have been overcome.

The average composition of "Bombay" and "Egyptian" undecorticated cotton cake is given by Dr. J. A. Voelcker as follows:

	Undecorticated cotton cake. "Bombay."	"Egyptian."
Moisture	11·6	12·3
Oil	4·6	5·1
Albuminous compounds [1]	19·4	22·9
Digestible carbohydrates, etc.	38·0	33·7
Woody fibre	20·1	20·7
Mineral matter	6·3	5·3
	100·0	100·0
[1] *Containing nitrogen*	3·1	3·6

LINSEED

World's Production

The production of linseed in the chief producing countries of the world during the years 1911 to 1914, according to the *Annuaire International de Statistique Agricole*, was as follows:

Exporting Countries

	1911.	1912.	1913.	1914. (Returns not yet completed.)
	Tons.	Tons.	Tons.	Tons.
Argentina	572,400	1,130,000	995,000	1,125,500
Russia [1]	569,031	621,973	703,490	—
India	570,206	650,067	547,243	388,333
Canada	255,928	663,728	445,508	182,257
United States	492,017	713,082	453,484	395,214
Uruguay	22,317	33,073	24,451	14,000

[1] *European and Asiatic.*

Countries whose Imports exceed their Production

	1911	1912.	1913.	1914. (Returns not yet completed.)
	Tons.	*Tons.*	*Tons.*	*Tons.*
Roumania	14,229	18,233	13,445	3,906
Austria-Hungary	22,496	16,524	15,453	—
France	12,608	14,640	7,626	—
Belgium	13,085	13,055	9,824	—
Italy	8,660	8,720	10,300	8,200
Netherlands	14,290	10,557	8,276	—

Algeria, Morocco, China, Bulgaria, Japan, Turkey and Sweden produce small quantities of linseed.

World's Exportable Surplus

The following table shows the quantities of linseed exported from the chief linseed-producing countries of the world during the years 1909–13:

	1909.	1910.	1911.	1912.	1913.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Argentina	918,413	654,299	442,982	515,400	1,016,732
Uruguay[1]	—	16,776	22,317	33,073	24,451
India	233,859	370,552	522,023	354,490	413,874
Russia	96,064	140,885	158,064	164,419	107,074
Canada	16,363	47,114	63,587	34,989	235,435
United States	20,823	1,537	23	102	391
China	—	—	—	22,491	9,904
Total	1,285,522	1,231,163	1,208,996	1,124,964	1,807,861

[1] *Export figures are not available, so the whole output is taken as exported.*

The average annual exported surplus during the five years 1909–13 was therefore 1,331,701 tons, of which India contributed 29 per cent.

Chief Linseed-importing Countries

The imports of linseed into the chief linseed-importing countries of the world during the years 1909–15 are shown in the following table:

Year.	United Kingdom.	France.	Belgium.	Germany.	Holland.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1909	314,538	170,256	266,845	436,867	247,267
1910	281,158	141,736	200,096	320,522	191,484
1911	258,125	119,118	235,892	276,343	171,166
1912	264,170	151,905	223,032	330,092	208,929
1913	606,308	251,402	259,104	560,323	286,034
1914	454,033	133,656	—	—	—
1915	393,779	37,181	—	—	—

The following table shows the relation which these imports bear to the world's exportable surplus as estimated above:

Year.	World's exportable surplus.	Proportion of the world's exportable surplus represented by the imports into				
		United Kingdom.	France.	Belgium.[1]	Germany.	Holland.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1909 .	1,285,522	24·5	13·2	16·5	34·0	19·2
1910 .	1,231,163	22·8	11·5	11·5	26·0	15·6
1911 .	1,208,996	21·4	9·9	13·5	22·9	14·2
1912 .	1,124,964	23·5	13·5	12·7	29·3	18·6
1913 .	1,807,861	33·5	13·9	8·6	31·0	15·8

[1] *Corrected for re-exports to Germany.*

Italy, Austria-Hungary and Australia each import about 40,000 tons per annum.

The following table shows the percentages of the imports of linseed into the United Kingdom derived from the chief contributing countries:

Imports of Linseed into the United Kingdom

(A) QUANTITIES

From	1912.	1913.	1914.	1915.	1916.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Russia	48,155	18,379	21,163	2,659	12,607
Argentina . . .	71,825	208,679	190,299	235,951	169,180
India	118,377	126,472	205,265	147,329	280,438
Canada	1,801	236,606	20,995	145	323
Total from all countries .	264,170	606,308	454,033	393,779	462,548

(B) PERCENTAGES

	1912.	1913.	1914.	1915.	1916.
Russia	18·2	3·0	4·7	0·7	2·7
Argentina . . .	27·1	34·4	41·9	60·0	36·3
India	44·8	20·8	45·2	37·4	60·2
Canada	0·7	39·0	4·6	0·0	0·1
Total from above countries .	90·8	97·2	96·4	98·1	99·3

Canada's production and export of linseed have fluctuated greatly. The United States is the chief destination of Canada's exports. The export of linseed from Russia to be expected in the future may be reckoned at about 100,000 to 150,000 tons a year, whereas Argentina is apparently capable of producing for export 1,000,000 tons and upwards.

The average contribution of linseed from India to the

United Kingdom in the five years 1912–16 was over 41 per cent. of the total imports.

It does not seem likely that the linseed-producing countries of the Empire will in the near future provide more than 50 or 60 per cent. (40 from India, 10–20 from Canada) of the requirements of the United Kingdom, assuming the latter to be about 520,000 tons per annum. Russia should be able to provide from 20,000 to 50,000 tons a year. The remainder will have to be obtained from Argentina, and in view of large British investments there it seems likely that considerable quantities will be obtained from Argentina.

Cultivation of the flax plant for seed has given encouraging results in British East Africa, but in view of the preoccupation of East Africa with flax fibre, seed is not likely to be produced in quantity there. Japan is another country in which the production of flax and possibly of linseed may make rapid progress.

Trade of India

The export of linseed from India was first recorded in 1832, when 3 cwts. were exported. In 1850 the exports amounted to 28,000 tons, in 1880–1 to 299,000 tons, and the high-water mark was reached in 1904–5 with 559,000 tons. At one time India held the dominant position in the world's trade in linseed, but now Argentina is the largest producer, and the United States of America, Canada and Russia all turn out large crops.

The Indian exports are, however, still of great importance in the world's linseed trade, forming nearly 30 per cent. of the exportable surplus of the world.

Linseed is sown either by itself in India or as a mixed crop. The estimates of the outturn of linseed from pure and mixed crops for the years 1911–12 to 1916–17 were:

	1911–12.[1]	1912–13.[1]	1913–14.	1914–15.	1915–16.	1916–17.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Pure .	502,000	410,600	327,200	287,000	346,000	382,000
Mixed .	140,000	128,000	59,000	110,000	130,000	138,000

[1] *Excluding Punjab, which in subsequent years produced from* 3,000 *to* 4,000 *tons.*

The exports of linseed from India in recent years are shown in the following table:

Exports of Linseed from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity, *tons*	522,023	354,489	413,874	321,577	192,987	394,103
,, value . £	8,643,277	5,318,383	4,457,998	3,502,411	1,982,782	4,759,957
To	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom .	154,931	110,316	157,315	206,109	144,755	308,968
Australia . .	877	2,605	3,360	3,417	7,389	10,550[1]
Total, British Empire	158,422	113,040	160,855	211,014	152,383	—[2]
Belgium . .	119,990	83,821	38,459	24,418	—	—
France. . .	80,832	70,192	115,460	39,716	18,848	47,254
Italy . . .	30,060	25,607	30,657	31,137	12,180	22,582
United States .	68,481	8,688	—	—	900	2,766
Germany[3] . .	40,159	33,171	48,326	10,053	—	—
Austria-Hungary[4].	8,268	5,186	6,500	891	—	—
Holland[5] . .	13,162	11,278	9,576	1,149	—	—

[1] *Including New Zealand.* [2] *Figure not available.*

[3] *Germany imported considerable amounts of linseed from Belgium and Holland, some of which may have been of Indian origin. The figures given in the German Trade Returns for direct imports from India are much in excess of those in this table.*

[4] *The direct imports from India to Austria-Hungary shown in the Austro-Hungarian returns are in excess of these figures.*

[5] *Holland imported considerable quantities of linseed from Belgium, some of which may have been of Indian origin.*

It will be seen that in the pre-war years the bulk of India's trade in linseed was with the Empire and Allied countries. A large part, however, of the imports to Belgium went to Germany. In normal times about 80 per cent. of the Indian crop is exported.

Linseed Oil

A certain quantity of linseed is crushed in India. The oil obtained is said not to be equal to that manufactured in the United Kingdom, and railways and other large consumers of linseed oil find it necessary to import their requirements.

Exports of Linseed Oil from India

Year.	Quantity. *Gallons.*	Value. £
1910–11 . . .	316,111	42,594
1911–12 . . .	249,975	49,966
1912–13 . . .	106,867	20,823
1913–14 . . .	102,360	17,493
1914–15 . . .	132,796	27,869
1915–16 . . .	280,850	47,274
1916–17 . . .	178,257	32,829

Two-thirds of this trade is with countries in the British Empire—Hong Kong, Australia and New Zealand being the principal customers. In 1914–15 the United Kingdom took 29,000 gallons valued at £13,000, and in 1915–16 17,000 gallons valued at £8,000.

Imports of Linseed Oil into India

Year.	Quantity. Gallons.	Value. £
1910–11	342,067	50,919
1911–12	399,070	64,845
1912–13	364,961	56,401
1913–14	439,482	58,817
1914–15	360,484	49,781
1915–16	267,687	43,535
1916–17	134,922	29,570

The United Kingdom supplies practically the whole of the linseed oil imported into India. Although, as mentioned above, Indian linseed oil is said to be inferior to that manufactured in the United Kingdom, yet the value per gallon declared at time of export of the Indian oil is higher than the declared value of the British oil at time of import in India. The average value per gallon of the Indian produce at time of export in 1913–14 and 1914–15 was 3*s.* 5*d.* and 4*s.* 2*d.* respectively, whereas the value of linseed oil imported from the United Kingdom was 2*s.* 8*d.* and 2*s.* 9*d.* respectively for the same periods. The difference in value is extraordinary when it is remembered that freight and other charges have been paid on the imported oil.

Other Products of the Flax Plant

Linseed Cake.—The Indian returns do not show the export of this cake separately.

Fibre.—The plant is grown in India practically for linseed only, though trial cultivations for fibre have been made. The value of raw flax fibre and manufactures exported from India for the last five years averages less than £2,000 per annum. The imports of raw flax and manufactures on private and Government account averaged in value over £270,000.

General Remarks

It seems clear from the foregoing that there would be no difficulty about finding a market in the Empire for the whole of the linseed exported from India. It is not possible to determine precisely how much of India's exports of linseed went to Germany and Austria-Hungary, because there were direct and indirect imports, but it certainly did not on the average exceed 75,000 tons, which is about 16 per cent. of India's average export. On the contrary, the United Kingdom alone could take the whole of India's output, whilst there are probably considerable opportunities for an extension of the market for linseed (or linseed oil and cake) in Australia, New Zealand and the Union of South Africa. Australia is already a much better market than Austria-Hungary. The total market in the United Kingdom is much larger than appears on the surface, as the following figures show:

Average Annual Imports of Linseed (Raw and Semi-manufactured) into the United Kingdom during the five Years 1911–15

	Tons.
1. Net average annual imports of raw linseed, *i.e.* imports less re-exports	384,568
2. Net average annual imports of linseed oil (*i.e.* imports less re-exports) expressed in terms of raw linseed, linseed oil being taken as 35 per cent. of raw linseed	43,223
3. Net average annual imports of linseed cake (*i.e.* imports less re-exports) expressed in terms of raw linseed, cake being taken as 65 per cent. of raw linseed	93,419
Grand total	521,210

Allowing for the excess of cake from item 2, and the excess of oil from item 3, the net requirements annually in the years mentioned must have been about 460,000 tons.

Niger Seed

The plant which produces the niger seed of commerce is known botanically as *Guizotia abyssinica* (cf. this Bulletin, 1916, **14**, 96). It is native to tropical Africa, but is now cultivated in various parts of India, whence the bulk of the European supply is derived. The imports of niger seed into the United Kingdom and Germany are not separately

recorded in the official returns of trade, and it would therefore appear that the trade is of small importance. The figures given in the official returns of imports into France do not correspond with those given in the Indian returns; thus the French imports from India for the four years 1911 to 1914 averaged 2,260 metric tons, whilst the exports to France from India averaged 1,547 tons for the same period.

The following table shows the quantities and distribution of the niger seed exported from India during recent years:

Exports of Niger Seed from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.
Total quantity . *tons*	10,105	5,684	4,107	2,330	589
" value . . £	102,650	57,843	42,926	22,154	4,823
To	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom .	5,176	1,649	367	1,660	381
France	2,780	2,357	1,046	5	10
Italy	747	1,003	50	26	175
Germany	1,151	247	2,029	590	—
Austria-Hungary . .	199	399	566	—	—

In India, niger seed is produced chiefly in Chota Nagpur, the Central Provinces and the Deccan. In some parts of India it is known as kala-til (*i.e.* black til or sesame), and like sesame it is generally sown in July or August and cut in November or December. Apparently no official forecast is prepared showing the extent of the cultivation and the estimated yield.

It is largely sown as a mixed crop, and the outturn per acre depends on the proportion of the seed sown. In Chota Nagpur the average yield per acre was estimated at 330 lb. In 1885–6 it was estimated that 250,000 acres were devoted to niger seed in the Central Provinces. The export trade has never been on a large scale, and is not on the increase.

Niger seed yields a pale yellow oil, with little odour and a sweet taste. Comparing niger seed with rape seed the yield of oil is about 16 gallons per quarter against 20 gallons, and the average weight of the seed is about 8 lb. per bushel less than that of rape seed, which is an important question when estimating freight charges. The relative Indian export values of niger, sesame and rape seeds for the last five years were as follows:

Value per Ton

	1910–11.	1911–12.	1912–13.	1913–14.	1914–15.
	£ s.	£ s.	£ s.	£ s.	£ s.
Niger seed .	9 16	10 3	10 3	10 9	9 12
Sesame ,, .	13 3	14 5	15 12	16 0	15 4
Rape ,, .	9 8	10 0	11 0	11 9	11 2

Niger seed is largely crushed in India for the oil, which is used principally for cooking, anointing the body and for lighting, and, owing to its comparative cheapness, to some extent as an adulterant of sesame and other more valuable oils. In its drying properties the oil ranks between cotton-seed and linseed oils. The cake which is left after the oil has been removed from the seed is used for cattle feeding in India and Europe.

The following analyses show the average composition of five samples of niger-seed cake compared with that of sesame cake of English and Burmese manufacture. The analyses of the niger-seed cake and the English sesame cake were made at the East Anglian Institute of Agriculture, Chelmsford; that of the Burmese sesame cake is quoted from "The Valuation of Feeding-Stuffs," by Alfred Smetham (*Journ. Roy. Lancs. Agric. Soc.* 1914).

	Sesame cake. Burmese manufacture.	Sesame cake. English manufacture.	Niger cake (average of five samples).
	Per cent.	*Per cent.*	*Per cent.*
Moisture	7·20	9·3	10·4
Fat	17·80	11·9	6·1
Protein	35·88	44·5	33·1
Starch, etc. (by difference) .	22·44	20·9	23·4
Woody fibre	4·43	4·5	16·8
Mineral matter (ash) . .	12·25	8·9	10·2
Food units [1]	156	162	121
Nutrient ratio [2] . . .	1 : 1·76	1 : 1·09	1 : 1·13

[1] *The food unit is the total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

[2] *The nutrient ratio is the ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

It will be seen that the trade in niger seed is of small importance, and there is little likelihood that the cultivation of the plant will be extended in India, as sesame, which is grown in the same localities, gives a better return. It should be possible for British oil-seed crushers to secure and utilise the small quantities of Indian niger seed which were formerly taken by Germany and Austria-Hungary.

Rape (Colza, Ravison, Tori) and Mustard Seed

The name rape seed, with its synonyms colza and ravison, is applied to the seed of a great number of varieties of *Brassica campestris* (with perhaps allied species), a plant nearly allied to the turnip and cabbage, which is widely grown in temperate, sub-tropical and tropical countries either for use as a green fodder or for the production of seed (cf. this Bulletin, 1915, 13, 452). True rape seed is liable to be confused with mustard seed (as in India and China), with wild rape or ravison, and with the so-called Indian rape seed (teora, tori, taramani or jamba) obtained from *Eruca sativa*. It is therefore convenient to discuss all these seeds together, and in this connection it should be noted that some of the statistics given in this statement may relate to pure and genuine rape seed and others to mixtures with mustard, ravison and tori seeds, but where such admixture is known the fact will be mentioned.

India, Russia and China produce most of the world's supply of rape seed, but Roumania, Bulgaria, the Dutch Indies and Argentina also make contributions to the exportable surplus. The plant is cultivated in many other countries both for seed and as green fodder.

The following table taken from the *Annuaire International de Statistique Agricole*, 1913 *et* 1914, gives the production of rape seed in the principal producing countries of the world:

Production of Rape Seed in the Chief Producing Countries

	Average for the five years 1905–9. *Metric tons.*	1910. *Metric tons.*	1911. *Metric tons.*	1912. *Metric tons.*	1913. *Metric tons.*	1914. *Metric tons.*
India (pure) .	562,402	764,474	682,987	710,725	694,773	727,388
,, (mixed)	365,370	473,478	570,002	618,773	559,842	322,247
Japan . .	131,179	125,766	126,057	122,612	108,882	—
Roumania .	48,774	91,535	41,878	36,275	51,814	38,574
France . .	48,027	47,531	41,930	29,951	—	—
Austria . .	30,337	21,164	18,159	17,259	13,832	—
Hungary .	18,860	28,890	28,059	—	—	—
Bulgaria .	6,917	2,272	14,463	14,657	—	—
Netherlands .	5,386	4,153	3,604	1,177	3,064	3,773
Belgium .	1,373	1,268	1,379	1,433	1,595	—

This table is incomplete, as it does not include Russia,

Argentina and China, all of which countries are producers and exporters of rape seed.

Russia.—A large quantity of wild rape or ravison grows in the north of Russia. The rape plant proper is extensively cultivated in Bessarabia and Southern Russia, and the seed is exported from Odessa and other Black Sea ports. More than half the trade, however, goes overland across the Western frontier to the Central European countries.

The following table shows the quantities and chief destinations of rape seed exported from Russia during the years 1913 and 1914:

Exports of Rape Seed from Russia

	1913. *Tons.*	1914. *Tons.*
Total quantity	59,021	27,855
To United Kingdom	19,622	15,368
Belgium	5,801	2,758
Holland	10,384	2,590
Austria-Hungary	5,229	393
Germany	15,945	5,826

Roumania.—Roumania produces a large quantity of rape seed known as "navette," and exports between 30,000 and 40,000 tons a year. The seed exported is classed as colza and goes principally overland to Germany, Austria-Hungary and Belgium.

Argentina.—The rape plant is cultivated in Argentina, and small quantities of the seed, classed as "turnip seed," are exported to Europe.

China.—China has exported rape seed in recent years. In 1912 the exports from Tientsin alone amounted to over 14,000 tons, and in the British Consular Report for that year the trade was referred to as new. The following table gives the exports from China for three years:

Exports of Rape Seed from China

	1913. *Tons.*	1914. *Tons.*	1915. *Tons.*
Total quantity	36,708	52,120	64,978
To Japan	16,448	26,889	61,663
France	9,268	12,785	—
Great Britain	4,562	6,712	949
Belgium	2,000	1,334	—
Italy	982	2,137	—
Germany	658	400	—
Austria-Hungary	2,282	797	—
Other countries	508	1,066	2,366

This trade will probably increase if the price of oil seeds remains high. Japan has secured a large share of the trade, and in this connection it is noteworthy that in 1915 and 1916 the United Kingdom imported from that country rape-seed oil to the value of £231,624 and £251,551 respectively.

The following table shows the quantities and principal countries of origin of the rape seed imported into the chief rape-seed importing countries in Europe:

Imports of Rape Seed to Chief Consuming Countries

To	1910. *Metric tons.*	1911. *Metric tons.*	1912. *Metric tons.*	1913. *Metric tons.*	1914. *Metric tons.*	1915. *Metric tons.*	Principal countries of origin.
Germany	187,302	134,480	125,684	153,427	—	—	India, Roumania
France	97,761	84,996	71,517	55,359	41,428	13,779	India
United Kingdom [1]	46,540	42,999	34,679	49,178	57,267	35,618	India, Russia
Belgium [2]	46,780	36,198	33,897	37,294	—	—	India, Roumania
Italy	—	6,702	3,209	10,182	21,980	—	India

[1] *Long tons.* [2] *Corrected for re-exports, which were sent chiefly to Germany.*

It will be seen from the above table that India as the chief producer is the principal source of the rape seed imported into European countries, and that before the war Germany was the most important market, followed by France, the United Kingdom and Belgium.

Indian Rape Seed

Many varieties of the plant are cultivated in India, but the three main varieties are sarson (Indian colza), tori (Indian rape, *Eruca sativa*), and rai (Indian mustard, *Brassica juncea*) (*Agric. Ledger*, No. 1, 1898). The crop is largely grown in the northern tracts of India, sometimes pure, but more often mixed with other crops. It is sown in October and November and cut in February and March. It is estimated that on an average over 6,000,000 acres, including the mixed crops of the United Provinces, are cultivated, of which the United Provinces contribute about 40 per cent., Bengal 22 per cent., Punjab 19 per cent., and Bihar and Orissa 10 per cent. The average yield is under 4 cwts. per acre; this does not, however, represent the outturn obtained when rape is sown as a pure crop.

The species most commonly grown in the United Provinces and the Punjab is sarson (Indian colza), producing white, yellow or brown seeds; tori (Indian rape), with smaller seeds of a bright brown colour, is also grown in these two Provinces, and more extensively in Bengal and Bihar. Rai (Indian mustard), with small brown seeds, is extensively cultivated in Bengal and to a less extent in the other Provinces; the seeds of this species are hard and yield less oil than the other kinds.

The seeds most largely exported from India are those obtained from sarson (either yellow or brown) and from tori (brown), and grown in the United Provinces and the Punjab. The following table shows the quantities exported from the various Indian ports for two years, and also the provincial production of seed for the same periods:

Exports

Port.	1912–13. Tons.	1913–14. Tons.
Calcutta	800	7,800
Bombay	52,600	52,200
Karachi	164,400	188,900

Production

Province.	1912–13. Tons.	1913–14. Tons.	
Bengal	265,800	266,200	Provinces served by the Port of Calcutta.
Bihar and Orissa	137,100	165,700	
Assam	58,400	61,300	
Punjab	156,600	165,000	Served by Karachi.
Sind[1]	4,600	42,000	
North-West Frontier Province	7,200	15,900	
United Provinces	584,900	350,000	Served partly by Bombay and partly by Karachi.
Bombay[1]	20,000	21,300	Served by Bombay only.

[1] *Including Native States.*

From the above statements it seems that the seed grown in Bengal, Bihar and Assam is that chiefly retained for local consumption. On an average the total annual outturn of seed in India is 1,200,000 tons, and in normal years the proportion of exports to total production is about 20 per cent.

It would appear, from various notes which have been written on the Indian plant, that the seed has deteriorated in several localities, and that there now exist many cross-

bred types. There is evidently much room for improvement, and larger outturns may be expected when the Indian Agricultural Departments have been able to deal more fully with the question of the change and selection of seed.

Summary of the Trade in Rape Seed

The Indian Trade Returns show that before the war India exported annually about 260,000 tons of rape seed; Germany was the most important market, followed by France, the United Kingdom and Belgium. Considerable quantities were also taken from India by Holland *via* Belgium. Details of the exports from India to the chief countries of destination in recent years are shown in the following table:

Exports of Rape Seed from India

	1910–11.	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity, *tons*	329,653	235,477	217,829	249,005	96,912	95,214	121,748
,, value . £	3,104,296	2,341,384	2,403,453	2,851,711	1,083,719	938,576	1,180,108
To	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom .	40,782	19,229	21,395	14,099	24,681	47,474	88,991
Total, British Empire	40,820	19,262	21,454	14,419	24,820	47,696	—[1]
Belgium[2] . . .	92,685	100,586	82,509	98,869	26,861	—	—
France . . .	79,471	60,113	53,144	53,943	20,593	40,280	23,426
Italy . . .	7,788	5,879	2,913	13,727	14,758	6,375	4,759
Germany . . .	92,993	40,596	54,712	58,199	8,107	—	—
Austria-Hungary .	6,189	4,027	1,247	5,472	700	—	—
Holland . . .	4,989	4,354	1,550	3,824	—	—	—
Spain . . .	1,243	409	250	550	1,060	700	—[1]

Average exports, 1910–11 to 1913–14, 258,000 tons.
,, ,, 1914–15 ,, 1916–17, 104,628 ,,

[1] *Figures not available.* [2] *Much of this eventually goes to Germany.*

According to the German Trade Returns Germany imported annually on the average 150,223 metric tons of rape seed during the years 1910–13 and re-exported 7,077 tons, giving 143,146 tons as the average annual consumption. Of this India supplied on the average 83 per cent., Roumania coming next with an average of 10½ per cent. Germany's net imports of Indian rape seed before the war were therefore equal to about 55 per cent. of the total Indian exports.

The total imports of rape seed, mustard seed, and ravison seeds into France during the years 1911 to 1914

averaged 63,325 tons and the re-exports 2,366 tons, leaving 60,959 tons as the average annual home consumption. This is roughly equivalent to 30 per cent. of the average total Indian exports during the same four years. India's share in the French imports of rape seed amounted to 85 per cent.

The Belgian Trade Returns indicate that the rape-seed trade of Belgium was largely transit trade to Germany and Holland, the average amount retained for consumption in the years 1910–13 being only 38,542 tons, of which 73 per cent. may be estimated as of Indian origin, assuming that Indian rape seed was retained for consumption in the same proportion as imported.

The quantity of rape seed retained for consumption in the United Kingdom was in the years 1911–14 on the average 44,543 tons, of which India contributed 18,808 tons or 41 per cent. The United Kingdom is, however, also a considerable importer of rape-seed oil and cake, and allowance should be made for this in estimating the home market. Before the war the United Kingdom took as much seed from Russia as from India.

Rape-seed Oil

The amount of oil in rape seed varies somewhat widely according to the variety of plant and the locality in which it is grown, the extreme range being from about 33 to 45 per cent. According to Lewkowitsch (*Technology of Oils, Fats and Waxes*) seed from the north of France contains 43 to 45 per cent., Danubian seed 38 to 40 per cent., and Indian seed 42 to 45 per cent. The commercial yield of oil may be taken as 36 per cent.

In spite of the number of varieties of plants which furnish seed used as sources of rape-seed oil, the character and analytical data of the oils do not differ to any great extent.

Rape-seed oil is growing in importance as an edible oil, as it can now be so refined as to make it suitable for use in the manufacture of margarine. In 1913 it was estimated that Germany used 478,000 gallons and Holland 239,000 gallons of colza oil for margarine.

Trade in Rape-seed Oil. Exports

The principal countries that export rape-seed oil are Germany, the United Kingdom, France, Japan and India. The quantities of the exports from these countries are shown in the following table:

Exports of Rape-seed Oil

From	1910. Gallons.	1911. Gallons.	1912. Gallons.	1913. Gallons.	1914. Gallons.	1915. Gallons.	1916. Gallons.
United Kingdom	1,227,636	1,507,815	1,331,397	1,418,877	1,659,690	1,470,150	953,261
Germany	2,139,050	1,371,382	540,857	989,460	—	—	—
France	—	561,650	387,658	418,087	407,168	170,198	137,206
Belgium[1]	—	488,899	429,244	—[2]	—	—	—
Japan	—	—	603,577	1,261,025	1,414,260	—	—
India[3]	378,978	377,824	377,563	406,890	426,956	459,458	552,119

[1] *Net exports.* [2] *Not shown separately.* [3] *Rape and mustard oil.*

India exports on the average about 400,000 gallons of rape-seed oil (including mustard-seed oil), almost all of which goes to British countries, the chief importers being Mauritius and Natal, which together take on the average 72 per cent. of the total. Large quantities are also sent to British Guiana and Fiji. Details of the exports from India are shown in the following table:

Exports of Rape-seed Oil and Mustard-seed Oil[1] from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity, *galls.*	364,228	414,217	407,178	413,189	46[illegible],735	574,328
" value . £	43,707	51,554	48,624	49,594	51,017	65,978
To	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	
United Kingdom	7,162	43,075	8,580	6,261	699	Figures not available.
Mauritius	161,343	178,192	189,651	205,989	220,977	
Natal	105,289	98,929	94,916	98,954	131,992	
British Guiana	16,565	26,270	31,267	20,727	23,525	
Fiji	43,989	40,366	41,329	47,782	22,570	
Straits Settlements	10,121	13,205	15,665	12,171	12,631	
Total British Empire	356,255	409,104	397,351	406,767	443,856	

[1] *The amount of mustard-seed oil is known to be small.*

The exports of rape-seed oil from Germany were on the whole declining before the war, due no doubt to use of the oil in Germany. The exports to the United Kingdom show a great falling off during the years 1910 to 1913. Taking the average amount of rape seed retained in Germany for consumption as 143,146 tons, and the average

export of rape-seed oil as 1,260,187 gallons (5,273 metric tons) and assuming that the seed yields 36 per cent. of oil, 14,647 tons or $10\frac{1}{4}$ per cent. of the seed worked in Germany is required for the export trade in oil, and of this 3,520 tons or 24 per cent. represents oil sent to the United Kingdom.

The United Kingdom exports a little less rape-seed oil (of home manufacture) than she imports, the average excess of imports over re-exports and exports for the years 1911 to 1915 being 416,405 gallons. There is obviously a considerable opening for India or the United Kingdom to secure Germany's export trade in rape-seed oil.

The United States imports considerable quantities of rape-seed oil, chiefly from the United Kingdom, France coming next and probably Germany next when allowance is made for Germany's share of the exports credited to Holland and Belgium.

Of the shipments of rape-seed oil from Japan in 1912 and 1913 the British Empire took 79 per cent., including Great Britain 51 per cent. This oil is expressed largely from seed imported from China, and there seems to be no reason why India should not compete to a greater extent for this trade. The Indian exports of oil have remained almost stationary, whereas those of Japan have increased rapidly.

Rape-seed Cake

The following table shows the quantities and countries of origin of the rape-seed cake imported into the United Kingdom:

		1911.	1912.	1913.	1914.	1915.	1916.
Total imports	*tons*	51,091	16,606	28,882	37,421	7,755	734
„ value	£	212,704	85,889	156,592	184,092	47,623	7,141
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
From British Possessions		244	120	23	250	496	—
Russia		43,481	14,293	25,839	34,455	—	—
France		—	—	—	—	1,459	—
Argentina		658	151	241	1,455	4,573	307
Other countries		6,708	2,042	2,779	1,261	1,227	427

Practically the whole of the rape-seed cake imported into and produced in the United Kingdom is consumed in this country; it is not possible to say how much goes into

compound cattle cakes, and how much is used as manure. The cake is a favourite manure for potatoes and root crops, and as a top dressing for wheat and barley. Rape-seed meal, from which the oil has almost entirely been extracted by solvents, is largely used for manurial purposes, especially by hop growers.

The cake is largely used on the Continent as a feeding-stuff for cattle, but in the United Kingdom there is a prejudice against it, due it is stated to the adulteration to which the seed has been subjected, and to the risk attaching to its use owing to the frequent presence in it of mustard seed. These complaints are made more commonly against cake from Indian seed than against that made from Russian seed. The cake has a somewhat pungent and bitter taste which is said to be disliked by cattle, but not by sheep.

The following typical analyses of rape-seed cake are taken from "The Valuation of Feeding-stuffs" by Smetham (*loc. cit.*). Analyses of linseed cake are added for comparison:

Name.	Water.	Oil.	Albuminoids.	Digestible carbo-hydrates.	Woody fibre.	Mineral matters.	Sand and silica.	Food units.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Rape-seed cake, Punjab .	7·75	13·27	37·25	28·46	5·90	7·37	2·15	155
" " Bessarabia	8·10	12·27	33·13	27·32	9·83	9·35	4·15	141
" " Brown E. Indian extracted . .	12·01	3·10	35·12	33·00	8·47	8·30	1·80	128
Brown colza cake, Cawnpore	6·55	6·87	35·63	34·15	6·30	10·50	2·75	140
Ravison cake . . .	7·30	7·10	33·12	29·16	12·27	11·05	4·90	130
" " Dnieper .	8·70	12·13	36·75	30·29	6·78	5·35	0·90	152
For comparison.								
Linseed cake, English made, average . .	11·16	9·50	29·50	35·54	9·10	5·20	0·60	133
Linseed cake, Bombay .	9·60	10·32	30·83	33·86	8·22	7·17	1·92	137
" " Calcutta .	9·25	9·83	33·25	34·82	5·70	7·15	2·20	142
" " Galatz .	10·75	9·53	37·25	29·51	8·16	4·80	0·15	146
" " Russian .	11·70	9·70	35·25	30·35	7·70	5·30	0·60	143

General Remarks

Taking the average annual export of rape seed from India before the war as 260,000 tons, Germany, France, Belgium and the United Kingdom divided this supply among them in about the following proportions; Germany

40 per cent., France 24 per cent., Belgium 11 per cent., United Kingdom 7 per cent., leaving for other countries about 18 per cent. The only country which could clearly increase its imports from India considerably is the United Kingdom, which took large amounts of rape seed and rape-seed cake from Russia and of rape oil from Germany. Apart from this there is not much chance of finding a market for the Indian rape seed which used to go to Germany, unless it finds a new outlet in the United Kingdom, Holland, Scandinavia and France, especially for the production of edible oil, either in the refined form or after conversion into a solid fat by hydrogenation.

Indian Mustard Seed

The Indian trade statistics show the export of mustard seed separately; the average quantity exported is about 4,000 tons. In 1913–14 the average export value of mustard seed was 13*s*. 10*d*. per cwt. as compared with 11*s*. 6*d*. per cwt. for rape seed. The bulk of the exports go from Bombay, and France is the chief customer.

The following table gives details of quantities and the chief countries of destination of the exports of mustard seed from India:

Export of Mustard Seed from India

		1910–11.	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity	*tons*	3,968	4,432	3,653	5,104	2,553	3,178	6,074
Total value	£	71,585	77,180	60,580	70,724	40,400	55,778	116,977
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom		24	52	6	900	10	170	Figures not available.
Ceylon		139	168	263	312	177	205	
Total to British Empire		242	318	359	1,295	298	489	
Belgium		764	923	676	1,029	355	—	
France		2,081	2,375	1,723	2,384	1,568	2,512	
Germany		433	530	780	328	170	—	

Poppy Seed (*Papaver somniferum*)

The poppy is extensively cultivated for opium in Macedonia (especially in the Salonica district), Asiatic Turkey, Persia, India and China; in all these countries the seed forms, however, a valuable secondary crop. In many parts of Europe a form of poppy is cultivated solely

for the sake of the oil-bearing seeds. The term maw-seed, probably a corruption of the German "mohr," is applied to the dark or "blue" seed of the poppy grown in Europe. The name is usually associated with the poppy seed used for feeding birds.

The world's production of poppy seed is difficult to estimate, as some of the producing countries do not publish full details. Some idea of the quantities entering the European markets may, however, be formed from the following tables which show the imports into France and Germany, the two most important countries utilising poppy seed, and the exports from India, which is the chief producing country:

Imports of Poppy Seed into France

	1911. Metric tons.	1912. Metric tons.	1913. Metric tons.	1914. Metric tons.	1915. Metric tons.
Total imports	19,479	18,015	9,021	6,935	4,173
From					
India	18,848	15,718	8,206	6,526	
Turkey	196	2,296	768	348	
Other countries	435	1	47	61	

Imports of Poppy and Sunflower[1] Seed into Germany

	1910. Metric tons.	1911. Metric tons.	1912. Metric tons.	1913. Metric tons.
Total imports	19,759	26,713	16,403	20,586
From				
Russia	2,496	5,771	5,867	8,575
Turkey	3,130	3,814	2,183	2,428
India, etc.	13,211	13,489	7,178	8,887
China	284	1,609	520	99
Other countries	638	2,030	655	597

[1] *Separate figures for imports of poppy seed into Germany are not shown in the German Trade Returns. The imports of sunflower seed are, however, probably merely those from Russia shown in this table.*

Exports of Poppy Seed from India

Principal countries of destination.	1911–12. Tons.	1912–13. Tons.	1913–14. Tons.	1914–15. Tons.	1915–16. Tons.	1916–17. Tons.
United Kingdom	—	—	—	84	143	—[2]
France	19,400	17,800	10,700	4,175	6,635	5,253
Belgium[1]	10,200	2,900	4,800	1,360	—	—
Germany	4,560	2,400	3,300	960	—	—
Total exports	34,943	23,402	18,980	6,992	6,872	5,524

[1] *Probably largely re-exported to Germany.* [2] *Figure not available.*

In 1914–15 Italy took about 350 tons of Indian seed. France is the chief consumer and under normal conditions should be able to absorb the whole of the available supplies from India. Poppy seed is not shown separately in the China trade statistics, but the quantity available for export is probably small. In 1910 Germany took the whole of the exports from Salonica (about 4,000 tons), but the exports were then on the decline, on account of the increase in local consumption. Asiatic Turkey and Persia must produce large quantities of poppy seed. Since the outbreak of the war Germany has probably secured all the poppy and sesame seed grown in the Turkish Empire. India annually imports from 1,000 to 4,000 cwts. of poppy seed from Persia. This is classed under the heading "Imports for Home Consumption."

In 1903-4 the estimated area under poppy in India was 769,000 acres, but since then the area has been considerably curtailed on account of agreements with the Chinese Government in 1907 and 1911 for the gradual extinction of the export of Indian opium to China. The production of "Bengal" opium, under State control, is now restricted to the United Provinces, and the average area under poppy cultivation for the last five years was 186,715 acres. As the export of "Malwa" opium is now prohibited it is probable that the large areas, formerly under poppy, in Rajputana and Central India, have been devoted to other crops. The bulk of the seed hitherto exported from India was the produce of the poppies cultivated in British India, the Malwa poppy seeds being largely retained for local consumption.

The average yield of poppy seed in the United Provinces is estimated to be 5 to 6 maunds of 82 lb. each per acre. Taking the average outturn at 4 cwts. per acre, the following statement shows the estimated area under poppy in British India, the yields of poppy seed, the quantities exported and the average export values over a series of years:

Year.	Area under cultivation in British India.	Estimated yield.	Quantity exported.[1]	Average export value per ton.	
	Acres.	*Tons.*	*Tons.*	£	s.
1904–5	612,000	122,400	65,800	7	4
1910–11	383,000	76,600	43,400	13	6
1911–12	220,000	44,000	34,900	14	4
1912–13	197,000	39,400	23,400	15	16
1913–14	170,000	34,000	19,000	16	7
1914–15	179,000	35,800	7,000	13	4
1915–16	181,000	36,200	6,900	1[illegible]	6

[1] *Includes the seed obtained from the "Malwa" opium crop, of which certain quantities were exported.*

The above statement shows that the quantity of seed now available for export is limited. The average area under poppy for the last five years was about 189,000 acres, and if this acreage is maintained in the future the annual yield, at 4 cwts. per acre, will amount to 37,800 tons.

The seed obtained from the ripe capsules (after the removal of the drug) has a sweet taste, and is eaten in India, being largely employed in the manufacture of sweetmeats. The seeds from unripe capsules are said to be bitter and narcotic, and the oil extracted is also bitter.

A form of poppy is cultivated in France and other European countries, and the oil from these seeds is known as "huile d'œillette"; the oil obtained from the Indian and Turkish seed is known as "huile de pavot." In France the seed is usually pressed in the mills which also crush sesame seed, so that the oil often contains traces of sesame oil.

The residue, or cake, left after the oil has been pressed from the ripe seed is sweet and nutritious and used as a food for bullocks and sheep, but is not recommended for young stock or cows. It is said not to keep well and to be liable to become mouldy and acrid to the taste, and is alleged then to be more or less injurious to cattle.

The following analyses of poppy-seed cake and meal are taken from Smetham (*Journ. Roy. Lancs. Agric. Soc.*, 1914):

	Cake.	Meal.
	Per cent.	*Per cent.*
Water	10·15	9·95
Albuminoids	35·38	39·50
Oil	11·43	12·13
Digestible carbohydrates	20·04	16·24
Woody fibre	7·90	9·43
Mineral matter	15·10	12·75

Ground Nuts

The following table shows the exports of ground nuts from the principal producing countries of the world during the year 1913:

Exports from British countries.	Total exports. Metric tons.	Exports to France. Metric tons.
India	259,704	200,977
Gambia	68,935	42,826
Nigeria	19,639	531
Nyasaland	1	—
Sudan	719	—
Total	348,998	244,334
Exports from other countries.		
Senegal	229,962	165,973
French India[1]	107,238	88,792
China	69,178	21,230
Netherlands East Indies	20,141	7,509
Portuguese East Africa	3,467	—
Total	429,986	283,504
Grand total	778,984	527,838

[1] *Mainly the produce of British India.*

This table shows that in 1913 68 per cent. of all the ground nuts exported were shipped to France.

The returns of the imports into France during the same year record the arrival of 532,087 metric tons, which shows that the above table is not far from complete. Some of the difference between the figures would be explained by exports of ground nuts consigned to such places as Hong Kong and Singapore finding their way ultimately to France.

Germany appears second amongst the countries importing ground nuts, with, however, only about 7 per cent. of the world's total. Netherlands, Belgium and Austria-Hungary follow in the order named.

Indian Trade in Ground Nuts

The Indian trade in ground nuts, which had fallen very low at the end of last century, has since recovered, due largely to the introduction of disease-resisting varieties, and to the increase in demand throughout the world for edible oils, with a consequent great advance in price. The increased demand is stated to have been caused in recent

years by the discovery of processes for refining the oil expressed from the nut, which in the case of Indian ground nuts had previously been suitable only for soap making, but is now an important article of food, competing with olive oil and refined cotton-seed oil as a salad oil, and entering largely into the composition of margarine.

The quantity and value of ground nuts exported from India for the years 1904–5 and 1913–14 were:

1904–5.		1913–14.	
Quantity. *Tons.*	Value. £	Quantity. *Tons.*	Value. £
83,700	647,000	277,900	3,254,000

Average f.o.b. value in India per ton, 1904–5, £7 10s.; 1913–15, £11 14s.

The export of ground nuts, largely produced in British India, from the French port of Pondicherry, which in recent years has averaged about 86,000 tons, is not included in the British-Indian export figures.

The crop area and yield in India for 1914–15 was estimated at 2,413,000 acres and 947,000 tons of nuts in shell, giving an average yield of 879 lb. per acre. The yield of the 1913–14 crop was estimated at 749,000 tons.

The quantity and destination of exports for 1913–14, 1914–15, 1915–16 and 1916–17 were as follows:

	1913–14. *Tons.*	1914–15. *Tons.*	1915–16. *Tons.*	1916–17. *Tons.*
United Kingdom	480	4,348	2,520	—[1]
Belgium	16,608	3,243	—	—
France	222,380	109,108	165,799	119,439
Italy	1,225	6,353	2,928	—[1]
Germany	9,436	3,790	—	—
Austria-Hungary	10,706	6,972	—	—
Other countries	17,072	4,508	4,196	24,355
Total	277,907	138,322	175,443	143,794

[1] *Figures not available.*

The trade was affected by the war, and the reduction was due to the lack of transport facilities, high freights and the suspension of demand on the Marseilles market, where practically all the oil mills had been closed in August 1914, after the army mobilisation, and their output greatly reduced during the following months from September to December. A further difficulty was caused by the mobili-

sation of the Italian army, much of the labour used at Marseilles being Italian. Exports of oil and cake from France have also been prohibited to a large extent.

The lack of export facilities has not apparently affected ground-nut cultivation in India; the official forecast gives the area under cultivation in 1916–17 at 2,317,000 acres, an increase of over 400,000 on the average of the five preceding years. It is stated that the extension of cultivation has been stimulated by the steadily rising prices, and that in Madras the ground-nut crop is replacing cotton to some extent in the black cotton soils and is steadily spreading in the red soils.

Ground-nut Forecast for India

Province.	1915–16. *Acres.*	1916–17. *Acres.*
Madras . . .	1,145,000	1,833,000
Bombay . . .	266,000	226,000
Burma . . .	262,000	258,000
Total . . .	1,673,000	2,317,000

In 1850 about 4,000 acres were under ground nuts in the Arcot District of the Madras Presidency, but it was many years before it was recognised as a commercial crop. In 1882, 73,000 acres were under ground nuts, and in 1891 this had advanced to 279,000 acres. The bulk of the export trade, in the early years, was carried on through the port of Pondicherry to Marseilles, where the value of the ground nut was first recognised.

After 1891 disease made ravages in the indigenous variety of nut then in general cultivation, and in 1897–8 the area under cultivation had been reduced to 94,000 acres. Efforts were made both by Government action and private enterprise to introduce better varieties, the Pondicherry Chamber of Commerce especially interesting itself in the matter by bringing seed from Senegal. Eventually a variety obtained from Mozambique was found to be suitable and entirely replaced the original plant. It had the advantages of being better able to resist disease, of maturing within a shorter period, and of yielding a heavier crop, containing a larger percentage of oil. Within ten years of the introduction of the new variety the area under cultiva-

tion in Madras advanced from 94,000 acres to 838,000 acres, and the acreage has since been doubled. The cultivation of the nut soon spread to the neighbouring districts of the Bombay Presidency, but it was only taken up in Burma within the last fifteen years, and has made great progress.

The following figures show that India is a large consumer of ground nuts:

	1913–14. Tons.	1914–15. Tons.	1915–16. Tons.
Crop outturn	749,000	947,000	1,058,000
Exports, including those from Pondicherry . . .	364,000	190,000	218,000
Balance . . .	385,000	757,000	840,000

Owing to the dislocation of the export trade the bulk of the 1914–15 crop remained in India; it would appear, however, from the trade reports that although there were difficulties at first, a local market was found for the surplus. The yield in Burma for 1915–16 was estimated at 116,000 tons, and the exports from Burma for the last three years were: 1913–14, 26,900 tons; 1914–15, 1,900 tons; 1915–16, nil. Notwithstanding the fact that the entire outturn for 1915–16 and the bulk of the 1914–15 crop were available for consumption in the Province, over 2,000 tons of ground nuts were imported from Madras in 1915–16. Burma also imported during the same year 420,000 gallons of ground-nut oil from Madras, exporting only 75,000 gallons of oil to the United Kingdom.

The export of ground-nut cake from Burma, principally to the United Kingdom, was: 1913–14, 30,000 tons; 1914–15, 42,000 tons; 1915–16, 38,000 tons.

It would appear that the check in the export of the nuts has given an impetus to the manufacture of oil in India for local consumption, and the expansion in shipments of oil-cake supports this view.

In 1914–15 Calcutta imported 50,000 tons of ground nuts from Madras against 7,500 tons in the previous year; it was stated that the oil from the ground nut, being cheaper, was used in Bengal to mix with rape and mustard oil. Ordinarily Madras would have shipped these nuts to Marseilles.

The following table shows the quantities of ground nuts, ground-nut oil and cake exported from India for five years:

		1911-12.	1912-13.	1913-14.	1914-15.	1915-16.
Ground nuts	tons	191,000	243,000	278,000	138,000	175,000
Ground-nut cake	tons	—[1]	62,000	62,000	64,000	82,000
Ground-nut oil	gallons	179,000	227,000	288,000	223,000	373,000
Ground nuts from Pondicherry	tons	94,000	110,000	86,000	51,000	42,000

[1] *Not separately shown until* 1912-13.

Up to 1913-14 the exports of ground nuts were rapidly increasing. France was the chief customer, and for the four years 1910-11 to 1913-14 took on an average about 80 per cent. of the total exports. Belgium followed with less than eight per cent. (more than half of which was re-exported to Germany), and Germany and Austria-Hungary each with about three per cent. In 1914-15 the United Kingdom and Italy commenced to take an interest in the trade.

The Indian trade statistics do not distinguish between shelled and unshelled ground-nuts, but in order to save freight the bulk of the nuts are shelled before shipment.

In Europe the best grades of oil are made from nuts shipped in the shells and decorticated here, as with these there is less spoilage during the voyage. It is stated that the shelled nuts shipped from Madras arrive at Marseilles in a very bad condition, and that the oil obtained from them is practically all used for soap manufacture. Recently, however, it has been stated that even this oil is refined for edible purposes. This question is receiving attention in Madras; the heated condition of the ground nuts on arrival is attributed to the local method adopted of damping the nuts to facilitate shelling, and then not properly drying the kernels. Efforts are being made to introduce machines for shelling nuts, and already "machine-shelled" nuts are at a premium at ports of shipment. The Madras trade further suffers from the want of facilities afforded at the minor ports, from which the bulk of the nuts are shipped. The average quantities of ground nuts exported from the various ports serving Madras during the five years 1911-12 to 1915-16 were as follows:

	Tons.	*Per cent.*
Pondicherry	75,000	32·2
Madras	52,000	22·2
Cuddalore	51,000	21·6
Negapatam	26,000	11·2
Porto Novo	24,000	10·3
Other ports	6,000	2·5
Total	214,000	100·0

Madras is the only port at which cargo is shipped direct from the wharf to the steamer. At the other ports steamers have to lie a long distance from the shore, and, when weather permits, the cargo is shipped either in surf boats or lighters, and is often damaged in the process. The reason why greater advantage is not taken of the facilities offered at Madras is said to be that the railway system serving the ground-nut districts does not run into Madras; there is, however, a project for bringing the line into Madras. This question has been taken up by the Chairman of the Madras Port Trust. It is proposed to provide storage accommodation, and facilities for shelling and drying the nuts before shipment. If these proposals are carried out and the trade diverted to Madras, the nuts will be handled and shipped under better conditions to the advantage of both the grower and the trader. Certain improvements have already been effected and a much larger proportion of the ground nuts produced in the Presidency is now shipped from the port of Madras, as is indicated in the following table showing the exports in 1915–16:

	Tons.	*Per cent.*
Madras	75,636	39·0
Cuddalore	42,923	22·3
Pondicherry	42,238	21·9
Negapatam	19,805	10·2
Porto Novo	12,476	6·4
Other ports	396	0·2
Total	193,474	100·0

The season for the export of ground nuts from Madras is between the months of October and March.

The following table shows the principal customers for the ground-nut cake exported from India:

	1912–13. *Tons.*	1913–14. *Tons.*	1914–15. *Tons.*	1915–1916. *Tons.*
United Kingdom	25,000	33,000	44,000	43,000
Ceylon	17,000	15,000	14,000	35,000
Germany	17,000	14,000	4,000	—

The United Kingdom took practically all her supplies from Burma, where the oil-crushing industry is apparently being developed on sound lines. All the cake imported

from the East Indies is known in the home market as "Coromandel," as distinct from "Rufisque," a cake made from the West African nut. Ceylon obtains her supplies from Madras, and it is understood that the cake is largely used as a manure for tea. The quantity of cake produced and used in India is not known, but it must be very large, as the following facts will show. During the last pre-war year, 1913–14, the ground-nut crop in India was estimated at 749,000 tons, of which 364,000 tons were exported (including exports from Pondicherry), leaving a balance in India of 385,000 tons. Burma's share of the crop was 88,000 tons, of which 27,000 were exported and 61,000 tons retained; in the same year Burma exported 30,000 tons of cake. The rest of India retained 324,000 tons of nuts and exported only 32,000 tons of cake. In 1914–15, when the quantity of nuts retained in India was 757,000 tons, Burma exported 42,000 tons of cake and the rest of India 20,000 tons only. In India, oil-cakes, or "poonacs," are largely used for manure. This question was discussed at the Agricultural and Trade Conference held in Madras in December 1914. The officers of the Agricultural Department stated that the use of poonacs as manures for sugar-cane and for wet lands was spreading, and they considered this beneficial from an economic point of view, as it would lessen the call on cattle manure and liberate its use for other lands. It was estimated that four-fifths of the ground-nut cake produced is used as manure and one-fifth as fodder. In Europe ground-nut cake is regarded as a very valuable cattle fodder, and the manure produced by the animals fed on the cake is exceptionally rich in constituents of value to the farmer; but even in France much of the cake from ground nuts is used as a manure, due to the bad condition in which the nuts arrive. At the Madras Conference the question of the indirect manurial value of ground-nut cake was not discussed. Conditions in India, however, where the feeding of cattle is a minor consideration, are quite different from those existing in Europe. In places where village oil-presses are worked, the cultivator probably finds it economical to purchase the

cake for manure. The use of oil-cakes suitable for use as feeding-cakes as direct manures is not economical where cattle are raised and cheaper manures are available, and the continuance of this mode of use should not be encouraged. Burma exports practically all the ground-nut cake produced in the province, and she contributes more than half the cotton cake exported from India.

The exports from India of ground-nut oil have been very small, and have been confined to the supplies sent from Madras for the use of Indian coolies working in Ceylon and Mauritius. In 1915–16, however, Burma sent 75,000 gallons to the United Kingdom. Ground-nut oil is largely produced and used in India for domestic purposes.

General

The position of the Indian trade in ground nuts, therefore, is that the bulk of the Indian exports are taken by France, and that there is a large and increasing use in India itself. In 1914 when war broke out and the French market for ground nuts almost ceased to exist, the Technical Information Bureau of the Imperial Institute issued a statement on the subject of ground nuts to oil-seed crushers in the United Kingdom. Fair quantities of ground nuts are now being crushed in the United Kingdom, and there is a prospect of the demand increasing, but hitherto it has been met by imports from the West African Colonies and China rather than from India, mainly because of the bad condition of the Indian shelled nuts, to which reference is made above.

The total imports of ground nuts into the United Kingdom during the first ten months of 1917 amounted to 127,594 tons, valued at nearly £3,500,000, whilst the re-exports during this period amounted to only 1,370 tons, valued at about £30,000. Prior to 1917 the Trade Returns of the United Kingdom do not show the imports of ground nuts separately.

SESAME SEED AND OIL (*SESAMUM INDICUM*)

Sesamum indicum is an annual plant, which thrives both in the tropical and sub-tropical regions of the world, and

produces a small seed rich in oil, known commercially as til, gingelly, or sesame oil. It is cultivated extensively in India, China, and other countries in the Far East, in Asia Minor, Egypt, and in many parts of Africa, also in the tropical and sub-tropical regions of America. In most of these countries the crop is grown for local consumption and the seed is exported on a large scale from comparatively few countries, of which India and China are by far the most important.

Trade in Sesame Seed

The export of sesame seed from the chief producing countries in the last year for which statistics are available prior to the war were as follows:

From	Quantity. *Tons.*	Value. £	Chief countries of destination.
India (1913–14)	112,200	1,796,841	Belgium, France, Austria, Germany, Italy.
Sudan (1913)	6,750	107,672	Egypt (684 tons were re-exported).
East Africa Protectorate (1913–14)	3,800	58,564	Germany, India, Italy.
Uganda (1913–14)	900	10,449	Not stated.
China (1913)	121,100	1,868,717	Holland, Germany.
Manchuria (Darien) (1913)	2,000	36,481	Japan.
Indo-China (1913)	1,250	12,464	Hong Kong.
French Guinea (1913)	750	6,099	France.
Portuguese East Africa (Porto Amelia) (1912)	1,300	13,689	Not stated.
German East Africa (1912)	1,850	26,186	Zanzibar, Germany.
Turkey[1] (1912)	12,200	—	Not stated.

[1] *Complete statistics for the export of sesame seed from Turkey are not available; the figures given represent the exports from the following ports of Syria and Asia Minor: Haifa, Jaffa, Mersina, Adalia, Ayas and Smyrna.*

The following table shows the average annual export of sesame seed from India, and the share taken by France during the last forty years:

Period.	Average quantity exported annually. *Tons.*	Average annual quantity consigned to France. *Tons.*
1870–71 to 1874–75	39,000	33,000
1875–76 to 1879–80	66,000	50,000
1881–82 to 1884–85	116,000	90,000
1885–86 to 1889–90	100,000	70,000
1910–11 to 1914–15	100,000	32,700

For many years France took practically the whole of

the Indian exports; within recent years, however, other European countries have been drawing supplies from India. The presence of sesame oil, when mixed with other oils or fats, can be detected by a simple chemical test, and for this reason the addition of this oil to margarine was made obligatory in Germany, Austria, Belgium and Denmark, since when a considerable sesame-oil industry has been developed in these countries.

The following table shows the quantities and destinations of the sesame seed exported from India:

Exports of Sesame Seed from India

		1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity	*tons*	94,800	77,800	112,200	46,700	13,800	83,600
" value	£	1,350,861	1,215,783	1,796,841	711,853	164,170	1,083,723
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom		40	50	—	300	350	—[1]
Total to British Empire		1,800	1,700	2,400	3,300	2,300	—[1]
France		22,500	21,700	22,200	13,300	9,000	51,566
Belgium		21,500	17,500	33,800	5,500	—	—
Russia		100	200	1,300	4,100	—	—
Italy		13,000	5,400	14,300	9,500	1,700	8,483
Germany		10,600	8,500	16,500	1,900	—	—
Austria-Hungary		22,300	19,000	19,300	4,000	—	—

[1] *Figures not available.*

The following table shows the quantities and destinations of the sesame seed exported from China:

Exports of Sesame Seed from China

		1913.	1914.	1915.
Total quantity	*tons*	121,100	74,500	136,800
" value	£	1,868,717	887,100	1,239,300
		Tons.	*Tons.*	*Tons.*
United Kingdom		1,500	5,300	42,100
France		—	150	10,500
Belgium		830	150	—
Italy		6,550	4,000	42,000
Russia		500	500	2,000
Japan		4,500	6,900	13,900
Germany		41,200	23,200	—
Austria-Hungary		4,100	4,700	—
Denmark		—	5,600	17,500
Holland		60,300	22,500	4,100

It is only within the last ten years that China has

developed a large and steady export trade in this seed.

The total imports of sesame seed into Europe in 1913 amounted to roughly 250,000 tons, and the total imports into Germany for the same year were 114,174 tons. The quantities shipped direct to Germany from India and China in 1913 amounted to 57,700 tons, so it is evident that a part of the shipments consigned to Holland and Belgium must have been re-exported to Germany.

For many years France had virtually a monopoly of the crushing of this seed, but in 1913 her imports were 27,370 tons or 11 per cent. of the total European imports. Ground nuts have to a great extent replaced sesame seed at Marseilles; this may be due partly to the relative values of the two commodities, and to the fact that ground nuts are largely obtained from the French African colonies. The price of sesame seed has advanced more rapidly in recent years than the price of ground nuts, due largely to its enforced use in margarine in certain countries (*see* p. 402). In 1910–11 the relative export values of sesame seed and ground nuts in India were £13 3*s.* and £11 respectively; in 1913–14 the respective values were £16 and £11 14*s.* While the value of ground nuts had advanced by less than 5 per cent., that of sesame seed was nearly 18 per cent. higher.

After the outbreak of war the Indian exports fell from 112,200 tons in 1913–14 to 46,700 tons in 1914–15, and to 13,800 tons in 1915–16, but in 1916-17 they rose to 83,600 tons; the exports from China rose from 121,000 tons in 1913 and 74,500 in 1914 to 136,800 in 1915. Although the United Kingdom had hitherto imported very little sesame seed, the exports from China to this country in the early months of 1915 amounted to 42,000 tons. The prohibition against all re-exports of oil seeds from the United Kingdom largely stopped the Chinese export trade until autumn 1915, when improved shipping facilities allowed the accumulated stocks in China to be shipped at cheaper prices to Genoa. The exports from China to Italy in 1915 were 42,000 tons against 4,000 and 6,500 in the two previous years.

The following statement shows the declared export value of sesame seed at the time of export from India and China:

	India. Average value per ton.				China. Average value per ton.			Equivalent of the Haikwan Tael in English money.	
	£	s.	d.		£	s.	d.	s.	d.
1910–11	13	3	0	1913	15	9	0	3	0¼
1911–12	14	6	0	1914	11	18	0	2	8¾
1912–13	15	12	0	1915	9	1	0	2	7⅛
1913–14	16	0	0						
1914–15	15	4	0						

The great decline in the value of the Chinese seed is only partly accounted for by the fall in the value of the Haikwan Tael. Chinese seed is said to be equal to the Indian, and in 1913 there was little difference in the relative values.

The trade in sesame seed in the United Kingdom is not recorded separately in the Board of Trade Returns prior to 1917. In the first ten months of this year 20,000 tons were imported and 14,000 tons re-exported; the countries of origin of the seed and the destination of the re-exports are not separately recorded. The small quantities hitherto consumed in this country were chiefly used in the manufacture of compound feeding-cakes, the large quantity of the oil in the seed helping to raise the percentage of oil in the mixed meal. In other European countries the finer qualities of the oil are largely used in the manufacture of margarine, and if the margarine industry is developed in the United Kingdom the demand for the seed should increase, more especially if the use of sesame cake for milk production, and for fattening stock, can be popularised in this country.

The British oil industry could depend on a regular supply of seed, as the British Empire supplies nearly half the world's exportable surplus, and production can be largely increased. India always has a large available surplus, and with improved cultivation and better seed there is no doubt that larger shipments could be made. The Sudan and East Africa are also promising as future sources of supply.

Area and Yield in India

The following are official estimates of the area and yield of sesame grown as a pure crop in India:

	Area (acres).	Yield (tons).	Average yield per acre.
1915–16	4,008,000	392,000	219 lb.
1916–17	4,015,000	413,000	234 lb.

The estimate of the mixed crop, *i.e.* sesame grown interspersed with other crops, in the United Provinces, the only one which distinguishes the mixed from the pure crop, was:

	Area (acres).	Yield (tons).	Average yield per acre.
1915–16	1,100,000	90,000	183 lb.
1916–17	1,000,000	80,000	179 lb.

The above estimates do not include the crops grown in Burma, where over 1,000,000 acres are cultivated mainly in the dry zone, both as a separate and as a mixed crop. It is the most important oil seed grown in Burma, and the crop is retained for local consumption.

The average yield per acre from the unmixed crops in 1916–17 varied from 364 lb. in Bihar and Orissa and 305 lb. in Bombay to 165 lb. in the Central Provinces. In the United Provinces the average yield per acre in the case of the pure and the mixed crop was 224 lb. and 179 lb. per acre respectively; in the preceding year the corresponding figures were 269 lb. and 183 lb.

Sesame is very largely grown as a catch crop and mixed with other crops, and under the circumstances of its cultivation it is obviously impossible to frame any reliable estimate of its outturn per acre, which varies greatly with the amount of seed sown. The average yield for the so-called unmixed sesame appears to be very low and could undoubtedly be improved. As much as 1,230 lb. per acre has been recorded in Bihar and Orissa, whilst the average yield per acre of sesame grown experimentally in the Federated Malay States from seed imported from India was estimated at 150 gantangs or 950 lb.

In Indo-China (Annam) the yield varies from 300 to 800 kilos per hectare, equivalent to about 265 to 440 lb.

per acre, but with improved cultivation it is believed the outturn can be increased threefold.

Relative Value of Seed grown in Different Countries

The plant cultivated in the Levant produces a yellow seed of a larger size than the seed grown in India, and the finest quality of oil is obtained from this variety. The prices quoted for various descriptions of sesame seed at Marseilles during the first half of 1912 were as follows:

Bombay white, large seeds . . .	43.50 fr. per 100 kilos.
" " small " . . .	42.15 " "
" bigarre, 50 per cent. white	41.50 " "
Jaffa (Levant)	49.80 " "

Experiments might be made in India with Levant seed, and also with seed obtained from other parts of the world. It would appear that the varieties grown in India and Burma have deteriorated, and that better results, both as regards yield and quality, might be obtained by the introduction of fresh seed.

The following table gives the yield of oil said to be obtained on a large scale by the expression of sesame seeds. The seeds were expressed once or twice cold, and then once hot:

Description of seed.	*Yield per cent.*
Bombay seed, yellow or red	44 to 45
" " bigarre (mixed)	42 " 44
Levant	47 " 48
Chinese	44 " 45

Sesame Oil

In India and other eastern countries the oil, expressed by primitive methods, is largely used for culinary purposes, for anointing the body, and for lamps. India retains for local consumption on an average about 400,000 tons of sesame seed a year, and Burma about 100,000 tons. The quantities produced and retained in China and other eastern countries are not known.

India exports on an average about 180,000 gallons of sesame oil, principally to Ceylon, Aden and the Persian Gulf.

The following table shows the exports of sesame oil from India during the five years 1911–12 to 1915–16:

Exports of Sesame Oil from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.
Total quantity . *gallons*	166,847	149,651	208,053	188,553	141,301
" value . . . . £	20,746	20,355	28,699	25,462	17,490
To	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
United Kingdom	30	4,367	4,196	33	5,580
Aden and Dependencies .	2,550	20,453	35,647	43,374	29,720
Ceylon	34,054	27,238	31,609	30,020	22,371
Straits Settlements . .	10,793	6,711	15,367	7,981	8,146
Mauritius and Dependencies .	23,214	8,483	6,986	3,574	4,522
Total. British countries .	80,480	86,747	111,193	97,171	80,642
Turkey in Asia	4,563	392	4,439	10,430	2,390[1]
German East Africa . .	2,394	5,151	10,443	3,993	—
Maskat Territory and Trucial Oman	68,234	49,887	63,510	63,599	48,284

[1] *To Persian Gulf ports.*

In 1916–17 219,834 gallons of sesame oil, valued at £27,695, were exported from India; particulars as to the destination of the oil in that year are not available.

Sesame Cake

There is an export of sesame cake from India, but details as to quantities and distribution are not given separately in the Trade Returns, being included with linseed and rape-seed cakes.

CASTOR SEED (*RICINUS COMMUNIS*)

The castor-oil plant grows in many parts of the world, and, although it was long known and cultivated in India, it first came into prominence, as an article of commerce, early in the nineteenth century.

In 1804 the quantity and value of castor oil imported and sold at the East India sales was 20,207 lb., value £2,309, equivalent to about £1 2*s.* 6*d.* per gallon. The export of the oil expanded rapidly, but the first recorded export of castor seed was in 1877–8, when 4,521 cwts. were shipped. Since then the character of the trade has changed, as the following figures will show:

Exports from India

	Castor oil. *Gallons.*	Castor seed. *Tons.*
1879–80	2,651,889	11,880
1889–90	2,664,990	44,731
1913–14 . . .	1,007,000	134,888

It is evident that the primitive methods adopted for expressing the oil in India could not compete with the

methods introduced in Europe. The short-sighted policy of adulteration, commonly practised by the small dealers in India, also had an adverse influence on the Indian trade in the oil. The consumption of the oil in India is a large but unknown quantity. In India two principal varieties of the castor-oil plant are cultivated, the large and the small seeded. The medicinal oil is preferably obtained from the latter variety.

India is the chief source of supply of castor seed, and has in fact a practical monopoly of the world's export trade in this seed. The United States grow the plant for their own requirements, but also import large quantities of Indian seed. Small quantities have been imported into the United Kingdom from Brazil. The plant is cultivated in Manchuria and the seed crushed at Newchang (China). The exports of the oil from Newchang averaged 34,510 cwts. (about 390,000 gallons) for the years 1907–11. In 1912 the quantity and value of the oil exported was 42,885 cwts. and £46,399. The destinations are not mentioned in the Consular report from which the above information was obtained. Java and Indo-China are now growing the seed on a commercial scale, and attempts are being made to cultivate the plant in Russia and in the Transvaal and other parts of South Africa. The plant is found in Ceylon, the Congo, Uganda, East Africa, Rhodesia and elsewhere, but is not yet of commercial importance there.

The following table shows the export of castor seed from India in recent years:

Exports of Castor Seed from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity, *tons*	120,194	110,630	134,888	82,815	87,948	92,447
„ value . £	1,178,462	1,092,177	1,336,649	773,289	802,185	957,201
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom .	55,463	51,120	55,675	35,284	41,458	39,008
Total, British Empire	55,713	51,497	56,273	35,647	41,867	—[1]
Belgium . . .	14,415	10,209	14,822	5,669	—	—
France . . .	16,621	16,157	20,989	11,584	14,128	16,552
Italy . . .	13,073	6,461	11,789	11,203	7,788	10,585
United States. .	15,101	20,018	20,279	16,083	17,721	21,067
Germany . .	3,684	5,522	9,761	732	—	—
Austria-Hungary .	100	75	—	145	—	—
Spain . . .	960	466	975	1,300	1,834	—[1]

[1] *Figures not available.*

The United Kingdom absorbs nearly half the trade, but re-exports considerable quantities of the seed; for the three years 1911–13 her re-exports averaged 16,000 tons, shipped principally to Russia and to the United States.

The total imports of castor seed into the United Kingdom and the re-exports for the years 1911–16 were as follows:

	1911. Tons.	1912. Tons.	1913. Tons.	1914. Tons.	1915. Tons.	1916. Tons.
Imports .	64,957	55,772	60,276	50,834	27,815	40,951
Re-exports .	22,114	13,373	12,826	9,959	4,628	5,737
Balance .	42,843	43,399	47,450	40,875	23,187	35,214

The high-water mark of the Indian trade was reached in the year 1913-14 when France and Germany especially increased their demands. There has been a temporary set-back in trade due to the war, and this may lead to an increase in the production of oil in India. The bulk of the seed is exported from Bombay.

Castor Oil

Exports of Castor Oil from India

	1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity, *gallons*	1,404,403	954,495	1,007,001	898,269	1,451,655	1,723,469
,, value . £	131,221	90,285	92,504	83,550	129,301	174,110
To	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
United Kingdom .	149,094	112,688	87,256	53,960	698,280	1,121,735
Australia . . .	571,783	298,873	360,252	301,780	131,877	228,528
New Zealand . .	186,818	142,119	146,659	168,336	212,515	
Union of South Africa	133,909	82,571	59,659	57,490	73,291	—[1]
Mauritius . . .	109,233	89,309	92,050	104,654	118,696	—[1]
Straits Settlements .	107,518	119,186	141,414	108,120	91,740	85,970
Ceylon . . .	76,628	68,699	73,730	51,524	66,872	—[1]
Total, British Empire	1,346,397	926,742	971,711	853,258	1,408,030	—[1]

[1] *Figures not available.*

Australia and New Zealand are normally the chief customers. The United Kingdom is the only European country which takes notable supplies from India. Of other countries of the Empire to which the oil is sent the chief are the Straits Settlements, Mauritius, Union of South Africa and Ceylon. In 1916–17 the exports rose to 1,723,469 gallons, valued at £174,110, and in that year, as well as in 1915–16, the United Kingdom took much larger supplies than formerly. The war, with the consequent rise of freight charges, has given the Indian oil industry an

opportunity of increasing the production of oil rather than seed for export. The bulk of the oil is exported from Calcutta. Castor-oil mills are worked in many parts of India, as the oil is largely used by the people of the country and the cake finds a ready market as manure. The oil is chiefly used in India for burning in lamps, as a lubricant and for dressing leather, and in the manufacture of Turkey-red oil. Castor oil has largely been replaced by kerosene as an illuminant in India, and it has also felt the competition of mineral oils for lubricating purposes.

Imports of Castor Oil into the United Kingdom

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity, *galls.*	433,376	313,206	324,568	196,040	177,016	1,322,632
" value . £	57,398	40,122	41,875	25,542	28,261	249,125
From	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium* . . .	134,328	84,448	109,504	51,040	—	—
France . . .	77,024	72,404	78,880	52,896	53,128	1,160
Italy . . .	35,032	31,784	26,680	21,808	2,320	8,584
Other foreign countries .	27,608	23,432	32,480	22,040	3,016	92,336
British Possessions	159,384	101,152	77,024	48,256	118,552	1,220,552

The Board of Trade Returns do not specify the British countries from which the United Kingdom imports castor oil, but it is evident from the Indian export figures that India supplies the bulk (cf. table on p. 409). The quantities of castor oil re-exported from the United Kingdom are insignificant, but fair quantities of home-produced oil are exported.

Exports of Castor Oil—Manufacture of the United Kingdom

	1913.	1914.	1915.	1916.
Total quantity . *gallons*	2,509,776	1,789,880	710,848	715,488
" value . . £	301,839	202,025	109,101	175,321
To	*Gallons.*[1]	*Gallons.*[1]	*Gallons.*[1]	*Gallons.*[1]
Russia	2,088	15,544	122,032	102,080
Germany	1,551,152	926,144	—	—
Netherlands	413,888	244,528	57,536	6,264
Belgium	87,464	39,672	—	—
France	45,936	48,024	126,672	195,808
United States . . .	12,296	186,528	34,104	94,888
Other foreign countries .	208,104	219,472	164,256	69,368
Canada	103,704	50,344	104,168	116,000
Union of South Africa .	22,968	13,224	29,000	25,288
Other British countries .	41,296	46,400	73,080	105,792

[1] 232 *gallons of castor oil* = 1 *ton.*

Prior to 1913 exports of castor oil were shown under "other seed oils"; for the years 1911 and 1912 the total quantities entered under "other seed oils" were 1,702 tons (equivalent to 394,864 gallons) and 5,722 tons (equivalent to 1,327,504 gallons). For the years 1913, 1914, 1915, and 1916, when castor oil was separately recorded, the quantities were 2,509,776, 1,789,880, 710,848 and 698,320 gallons respectively. From this it would appear that the large export trade in castor oil in 1913 and 1914 was a new development. It would be interesting to ascertain why Germany took such large supplies of oil, amounting to nearly 2,500,000 gallons in 1913 and the first half of 1914. In the year 1913–14 she also drew from India nearly 10,000 tons of castor seed, more than double the average of the two preceding years. In 1913 the declared value f.o.b. of the oil shipped to Germany from the United Kingdom was £27 12*s.* per ton, whereas the value c.i.f. of the oil imported from Italy and France was £33 2*s.* 7*d.* and £32 4*s.* 9*d.* respectively. The oils imported from Italy and France must have been of a superior quality, as freight and other charges would not cover the difference in values. At the outbreak of war the effect of the closing of the German market to the British product was at once felt. Prices were then low at about £28 per ton for the pharmaceutical quality of the British oil, but as all European countries had difficulties in obtaining seed from India, and there was a large demand for war purposes, prices gradually rose to about £58 per ton in December 1915. The total exports in 1915 amounted to 3,064 tons, and in 1916 to 3,084 tons. Hull took about 81 per cent. of the total quantity of castor seed imported into the United Kingdom during 1912-16.

Castor-seed Cake

The quantity of castor cake produced in India is not known; the exports averaged between 5,000 and 6,000 tons up to 1914–15 at an average f.o.b. value of £4 per ton, but increased in 1915–16. They are sent chiefly to Ceylon, where the cake is used as a manure for tea. In India castor cake on account of the large amount of nitrogen it

contains is one of the most valued of oil-cakes as a manure, especially for crops of potato and sugar-cane; its value as a manure is also recognised by Indian tea planters. The cake has been used in India as fuel for stationary engines, and gas has also been obtained from the cake for lighting railway stations. It cannot, however, compete with cheap coal as a fuel. In China it is also appreciated as a manure, and the market gardeners in France consume from 15,000 to 18,000 tons annually, obtaining a part of their supplies from the United Kingdom. The export of cake from the United Kingdom is not separately recorded in the Trade Returns.

Character and Composition of Castor Seed, Oil and Cake

Castor seed contains from 46 to 53 per cent. of oil and yields by expression on a manufacturing scale about 40 per cent. of oil, about 33 per cent. being obtained at the first pressing. Most of the castor oil made in the United Kingdom is obtained by extraction with solvents.

Refined castor oil is almost colourless and has the following constants:

Specific gravity at $\frac{15{\cdot}5^\circ\ C.}{15{\cdot}5^\circ\ C.}$		0·959 to 0·969
Saponification value		176·7 to 186·6
Iodine value	*per cent.*	81·4 to 90·6
Reichert-Meissl value		1·1
Acetyl value		150·0

Castor oil differs from other vegetable oils in having a higher specific gravity and acetyl value. It is readily soluble in alcohol and almost insoluble in light petroleum, other vegetable oils being usually almost insoluble in alcohol and readily soluble in light petroleum. Castor oil, apart from its use in medicine, is chiefly employed as a lubricant and for the manufacture of Turkey-red oil for alizarine dyeing.

Castor seed contains a poisonous substance called ricin which remains in the cake or meal left after expression or extraction of the oil and renders this residue unsuitable for feeding live stock. Processes have been devised for removing the ricin, but so far there is no record of castor cake being used for cattle food. Its chief use is as a manure.

The composition of castor cake varies according to the extent to which expression or extraction of the oil has been carried, and depends also on whether it has been obtained from the whole seed or the decorticated seed, as is shown in the following table:

	Castor cake made from— Whole seed.	Decorticated seed.	Castor meal extracted by solvents.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	9·85	10·38	11·75
Ash	15·02	10·50	6·05
Oil	5·25	8·75	1·10
Proteins	20·44	46·37	30·62
Crude fibre	49·44	24·00	36·52
Carbohydrates			13·96
Phosphoric acid	1·62	2·26	—

The castor cake used as a manure in Southern India contains, on the average, the following percentages of constituents of manurial value: nitrogen 6·37, phosphoric acid 2·55, potash 0·96.

Mowra, Mahua or Mowa Seed

India has a virtual monopoly in the export of mowra or mowa seeds, but there are in tropical countries several other kinds of seeds yielding solid fats that could probably be used for purposes similar to those for which mowra fat is employed. The most important of these are "shea" nuts from West Africa, the Sudan, etc., which furnish "shea butter," and Illipé nuts from the Dutch East Indies and Borneo, from which tankawang fat or "Borneo tallow" is derived. Other possible competitors are the Sierra Leone butter seeds, *Pentadesma butyracea*, which are now beginning to be imported; Chinese "vegetable tallow" from the seeds of *Stillingia sebifera*; and "Piney tallow" obtained from the seeds of *Vateria indica*.

One of the uses of all these seeds is for the manufacture of edible fats, particularly chocolate fats, *i.e.* to replace or supplement the natural cocoa butter of cocoa beans in making cheap chocolate. It should be explained that the above statement is not to be taken as meaning that this practice is general among chocolate manufacturers. As is well known certain British chocolate manufacturers

regard such substitutes as unjustifiable, and do not countenance them. There is, however, little doubt that the practice is increasing. The relative suitabilities of these fats for this purpose are shown in the following comparative table of their principal constants, in most cases as determined recently on samples examined in the laboratories of the Imperial Institute.

The nearer the constants of any one of these fats approach those of cocoa butter the more suitable is that fat as a cocoa-butter substitute.

Source of fat.	Specific gravity.	Melting point.	Saponification value.	Iodine value.	Solidifying point of fatty acids.
Indian mowra seeds:					
Bassia latifolia fat	0·86	23°–31° C.	195	59	45° C.
B. longifolia fat	0·86	42° C.	198	57	45° C.
B. butyracea fat	0·86	39°–51° C.	197	40	51° C.
Borneo Ilipé seeds:					
Borneo tallow	0·85	32° C.	194	31	53° C.
Shea nuts:					
Shea butter	0·86	28°–29° C.	181	58	52° C.
Sierra Leone butter nuts:					
Sierra Leone butter	0·86	33° C.	190	42	51° C.
Stillingia sebifera seeds[1]:					
Chinese vegetable tallow	0·86	43°–46° C.	200–204	32·1–35·5	41°–53·5° C.
Vateria indica seeds[1]:					
Piney tallow	0·89	37°–42° C.	188·7–191·9	37·8–39·6	54·8° C.
Cocoa nibs:					
Cocoa butter	0·86	32° C.	192	35	49° C.

[1] *Lewkowitsch, "Chem. Tech. and Anal. of Oils, Fats and Waxes," Vol. II., 5th edition*, 1914.

It will be seen that all these fats are similar in character and, though each of them has certain minor disadvantages, they are all possible materials for the manufacture of chocolate fats. They are all, in addition, suitable for "stearin" candle manufacture. Most of the seeds have one disadvantage in common, viz. that the cakes or meals left after the extraction of the fats are bitter and believed to be harmful to animals. They cannot, therefore, be *recommended* for the production of feeding-cakes, though there appears to be no positive evidence that they are harmful. The value of the cakes and meals for feeding purposes requires further investigation.

The total trade in these seeds is small, and it is unlikely that the output can be increased largely, with the possible exception of shea nuts, because most of the trees bear seeds in a very uncertain fashion, and moreover do not as a rule occur close together. The crop is therefore always uncertain and collection difficult to organise. Further, the trees without exception are slow-growing, so that planting is not likely to be undertaken. It is possible, however, that with the development of transport facilities in Nigeria, Uganda and the Sudan there may be an increase in the output of shea nuts, and similar developments in Borneo may lead to an increase in the output of Illipé nuts. A considerable European trade in "vegetable tallow" already exists with China, and of recent years Malabar or "Piney" tallow from India has been receiving attention in continental Europe. On the whole, however, it does not seem likely that the trade in oil seeds of this type will ever rival in extent that of copra and palm kernels; at the same time the demand for such seeds is steadily increasing, and it will be worth while for India to increase the output of mowra seeds if that is possible.

Trade in Mowra Seeds

The following table shows the export and distribution of mowra seeds from India:

		1911-12.	1912-13.	1913-14.	1914-15.	1915-16.
Total quantity	*tons*	39,756	13,293	33,299	7,437	4,216
" value	£	392,350	142,913	363,634	50,674	24,327
To		*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom		303	—	—	5,312	851
Belgium		7,325	3,055	4,439	750	—
France		3,178	153	424	900	3,364
Italy		800	—	—	300	—
Germany		27,999	9,352	28,383	174	—
Holland		150	731	50	—	—

Trade in Shea Nuts and Butter

The following tables show the quantity and chief destinations of the shea nuts and shea butter exported from Nigeria during recent years;

Exports of Shea Nuts from Nigeria

		1911.	1912.	1913.	1914.	1915.
Total quantity	*tons*	3,629	7,756	9,419	6,335	9,572
" value	£	35,518	46,609	70,427	48,520	58,201
To		*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom		2,358	4,294	4,781	3,479	6,171
United States		—	—	—	—	3,400
Germany		174	193	2,987	2,856	—
Holland		1,097	3,269	1,637	—	—

Exports of Shea Butter from Nigeria

Total quantity	*lb.*	555,602	402,242	268,592	254,555	1,151,290
" value	£	4,978	4,797	4,044	4,323	11,622
To		*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
United Kingdom		8,484	19,717	16,830	38,027	633,883
Gold Coast		521,642	346,271	234,339	213,538	507,003
Other countries		25,476	36,254	17,423	2,990	10,404

The export of shea nuts at present takes place only from Nigeria. With improvement of railway facilities Nigerian supplies will increase. The tree (*Butyrospermum Parkii*) which yields the nuts occurs in the Gold Coast Colony and also in Ashanti, but owing to lack of transport facilities an export trade in shea nuts from these countries is not at present practicable, although large quantities of the nuts are available. Shea nuts are also produced in Uganda and the Sudan, where they are known as "Lulu" nuts, but no exports of these nuts are recorded in the Trade Returns of those countries.

Trade in Illipé Nuts and Borneo Tallow

The exports and distribution of Illipé nuts from Singapore are shown in the following table:

Exports of Illipé Nuts from Singapore

		1911.	1912.	1913.	1914.	1915.
Total quantity	*tons*	1,418	12,356	413	10,735	12,337
" value	£	18,262	225,973	5,954	228,524	232,682
To		*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United Kingdom		336	4,927	46	1,872	6,012
Belgium		661	2,968	316	5,247	—
France		421	2,584	—	3,515	6,325
Germany		—	1,824	—	—	—
Other countries		—	53	51	101	—

The chief countries of origin of the Illipé nuts re-exported from Singapore are shown in the following table:

Imports of Illipé Nuts into Singapore

		1911.	1912.	1913.	1914.	1915.
Total quantity	tons	1,495	10,404	230	10,010	11,357
„ value	£	18,432	164,990	3,058	176,440	182,716
From		Tons.	Tons.	Tons.	Tons.	Tons.
Sarawak		344	4,359	1	2,298	3,482
Dutch Borneo		618	5,831	28	5,192	7,028
Sumatra		521	212	197	2,466	833
Other countries		12	2	4	54	14

The trees which yield Illipé nuts belong for the most part to the Nat. Ord. Dipterocarpaceæ and include several genera. Some of the nuts are, however, furnished by trees belonging to the Nat. Ord. Sapotaceæ, the order to which Bassia belongs, and these are therefore closely related to the trees yielding the mowra seeds of India. There is a small, non-European trade in Borneo tallow.

Trade in Chinese Tallow

The following table shows the quantities of vegetable tallow exported from China during recent years; the seeds from which the vegetable tallow is prepared are apparently not exported as such.

Exports of Vegetable Tallow from China

		1911.	1912.	1913.	1914.	1915.
Total quantity	tons	2,678	12,758	13,154	11,313	10,801
„ value	£	64,590	356,146	342,405	283,154	254,470
To		Tons.	Tons.	Tons.	Tons.	Tons.
Great Britain		1,104	4,467	4,059	1,074	4,285
Germany		140	594	1,621	2,049	—
Netherlands		153	524	1,592	2,197	50
Belgium		—	672	1,047	716	—
France		53	1,154	1,540	2,095	1,056
Italy		758	3,131	1,754	1,576	1,765
United States		277	1,847	1,145	1,403	3,486
Other countries		193	369	396	203	159

Chinese vegetable tallow is the hard fat which coats the seeds of *Stillingia sebifera*. The seeds themselves

contain an oil—"Stillingia" oil, or "tallow-seed" oil. The hard fat separated from the seeds is known to European candle-makers as "prima" vegetable tallow. When the seeds together with their coating of fat are crushed, a mixture of vegetable tallow and Stillingia oil is obtained which is softer and has a lower melting-point (26° C. to 32° C.) than the true vegetable tallow; this is known as "secunda" vegetable tallow.

The Chinese tallow-tree is cultivated in North-West India, and has become almost wild in some parts. It was at one time thought that the tallow might be produced on a commercial scale in India, but all the experiments so far made have proved that the cost of extracting the fat is too high to make the industry profitable.

Indian Trade in "Piney" or Malabar Tallow

The fat or tallow known as "Piney" or Malabar tallow is derived from the seeds of *Vateria indica*, a large evergreen of the forests of the Western Ghats from Kanara to Travancore. The fat is extracted by grinding the roasted seeds and boiling the meal with water; the melted fat then rises to the surface and is skimmed off.

Locally the fat is used for the manufacture of candles and for adulterating ghi and also in medicine.

No export of this product is shown in the Indian Trade Returns, but it is stated in a United States Consular Report that prior to the war it was employed on the Continent in confectionery, the chief market being Antwerp.

Trade in Sierra Leone Butter Seeds

At present the trade in the seeds of the Sierra Leone butter tree, *Pentadesma butyracea*, is small, and no exports are recorded in the Trade Returns of Sierra Leone. The solid fat obtained from the seeds is known locally in Sierra Leone as Mandingo butter, and is occasionally brought to Freetown for sale. Trial consignments are known to have been sold in this country.

The Indian Trade in Mowra Seeds

Within recent years a considerable export trade in mowra seeds has been developed in India, and about 90 per cent. of this trade passes through the port of Bombay. The most common species of the mowra tree in India is *Bassia latifolia*, a large deciduous tree, to be found in the forests and outskirts of villages in the Central Provinces, Chota Nagpur, and many parts of the Bombay Presidency and Western India. It also grows in the Western districts of Bengal and in Upper India. It thrives best in dry stony ground, and is conserved and protected by the Forest Department and by village communities.

Another species is *Bassia longifolia*, a large evergreen tree, common in Southern India and Ceylon. A third species is *Bassia butyracea*, which grows in the Sub-Himalayan tracts. It may be assumed that *Bassia latifolia* supplies the bulk of the mowra seed exported from Bombay, that the exports from Madras ports are obtained from *Bassia longifolia*, and those from Calcutta from *Bassia latifolia*.

The following table shows the exports of mowra seeds from each Indian port concerned:

	1910–11. *Tons.*	1911–12. *Tons.*	1912–13. *Tons.*	1913–14. *Tons.*	1914–15. *Tons.*	1915–16. *Tons.*
Bombay .	15,104	36,223	12,671	31,705	6,905	4,050
Calcutta .	4,607	3,059	122	267	431	—
Madras ports	1,072	474	500	1,327	101	166
Total ..	20,783	39,756	13,293	33,299	7,437	4,216

The collection of mowra seeds is always a difficult problem, as the regions where the trees are most extensively found are generally inaccessible and sparsely inhabited In some of the forests of the Bombay Presidency the seeds are collected departmentally; the total quantity so collected in 1913–14 was, however, only 562 tons against the total exports of 33,299 tons for the same year. A statement made by the Forest Officer of North Khandesh that the crop seems to be poor and good in alternate years is borne

out by the following statement of the quantities of seed exported during the last eight years :

Export of Mowra Seed from India

Year.	Tons.	Year.	Tons.
1907–08 . .	39,760	1908–09 . .	20,360
1909–10 . .	39,200	1910–11 . .	20,783
1911–12 . .	30,756	1912–13 . .	13,293
1913–14 . .	33,299	1914–15 . .	7,437

The crop for 1914–15 was said to have been a poor one, and the export trade was restricted by the war. It seems very probable that a large quantity of the seed is now lost in the jungle, where it either rots or is eaten by wild animals. To secure the collection of this material the industry, which is now a minor one, requires to be organised. Hitherto Germany has taken the bulk of the Indian supplies; in 1913–14 she took 28,383 tons, or 85 per cent. of the total exports, and Belgium absorbed nearly the whole of the balance. In 1910–11 the exports to the United Kingdom amounted to 1,616 tons, but in the two subsequent years exports to this country stopped. In 1914–15 the exports to the United Kingdom were 5,312 tons, or about 70 per cent. of the total trade, but in 1915–16 it fell to 851 tons, or 20 per cent. of the total, the remaining 80 per cent. being sent to France. It is not known whether the seed was retained for home consumption or re-exported, as mowra seed is not separately shown in the United Kingdom Trade Returns.

Copra

In considering means of increasing the usage of Indian copra within the Empire it is necessary to bear in mind the fact that copra can be produced in practically any tropical country which has a seaboard, and that the quantity shipped from India, although important, is only one-seventh of the world's total exports.

The world's annual exportable surplus of copra is about 540,000 tons. This does not include copra crushed in India, Ceylon and elsewhere, and exported in the form of

oil and cake. This exportable surplus of copra was made up in 1913 (the latest year for which normal figures are available) as follows:

Exports of Copra from the Principal Copra-producing Countries of the World, 1913

	Tons.
British Countries	157,527
Allied "	104,020
Enemy "	32,377
Neutral "	243,500
Total	537,424

From British Countries

Ceylon	55,865
India	38,192
Federated Malay States	9,269
Unfederated Malay States	19,208[1]
Seychelles	2,938
Tonga Islands Protectorate	3,426
Fiji	7,929
Papua	845[2]
Solomon Islands	4,196
Gilbert and Ellice Islands	3,500
East Africa Protectorate	1,564
Zanzibar	9,451
Gold Coast	629
Trinidad	515
Total	157,527

From Allied Countries

	Tons.
French Indo-China	5,645
French Oceania	9,011
New Caledonia	2,960
Portuguese East Africa	4,000[2]
Philippine Islands	80,904
Samoa (American)	1,500[2]
Total	104,020

From Enemy Countries

Samoa (German)	11,021[3]
E. Carolines, etc.	4,747[3]
German New Guinea	11,190[3]
W. Carolines, etc.	1,085[3]
Togoland	161[3]
German E. Africa	4,173[3]
Total	32,377

From Neutral Countries

Netherlands East Indies	243,500

[1] *Including an estimate of* 12,500 *tons for Johore.*
[2] *Estimated.* [3] 1912 *figures.*

Other countries whence a little copra is exported, regularly or occasionally, are Mexico, the Republic of Dominica, Haiti, Venezuela, Colombia, Honduras, Ecuador, Jamaica, British Guiana and British Honduras.

The share of India in this exportable surplus of copra for 1913 is, therefore, about 7 per cent., and that of the British Empire nearly 30 per cent.

The exports of copra from the British producing areas in 1914 and 1915 are shown in the following table so far as figures are available:

From	1914. Tons.	1915. Tons.
Ceylon	70,397	60,426
India	31,845	15,678
Federated Malay States	14,500	13,342
Unfederated Malay States	18,342	16,070
Seychelles	3,174	2,915
Tonga Islands Protectorate	3,500 [1]	3,500 [2]
Fiji	9,429	15,238
Papua	1,003 [1]	635 [1]
Solomon Islands	4,000 [1]	4,000 [2]
Gilbert and Ellice Islands	4,500	5,000
East Africa Protectorate	1,586	1,386
Zanzibar	9,978	10,286
Gold Coast	656	770
Trinidad	1,052	1,780
Jamaica	32	85
Total	174,484	151,111

[1] *Estimated.* [2] *Figures for preceding year.*

The chief importing countries for copra in 1913 were as follows:

	Imports. Tons.	Re-exports. Tons.	Retained. Tons.
United Kingdom	30,868	16,664	14,204
Australia	5,861	517	5,344
France	123,360	11,032	112,328
Russia	66,690	—	66,690
Belgium	19,552	6,958	12,594
Germany	196,449	549	195,900
Austria-Hungary	33,605	—	33,605
Holland	100,635	82,356	18,279
United States	15,298	—	15,298

It is clear from these figures that the chief copra-importing and using countries in normal times are Germany (195,900 tons) and France (112,328 tons).

The position of the United Kingdom, Holland and the United States has altered considerably during the war, and all these countries are now importing and crushing more copra.

United Kingdom.	Imports. Tons.	Re-exports. Tons.	Retained. Tons.
1913	30,868	16,664	14,204
1914	66,494	24,334 [1]	42,160
1915	118,540	75,111 [1]	43,429
1916	62,400	12,089	50,311

[1] *Chiefly to Holland.*

Holland.			
1913	100,635	82,356	18,279
1914	110,311	77,130	33,181

United States.	Imports. Tons.	Re-exports. Tons.	Retained. Tons.
1912–13	15,298	—	15,298
1913–14	20,284	—	20,284
1914–15	40,243	79	40,164
1915–16	49,142	57	49,085

France and Russia, on the contrary, are importing and using less. The imports into Russia fell from 66,690 tons in 1913 to 38,309 tons in 1914.

The change of the position of the trade in Australia is shown in the following table :

	Imports. Tons.	Re-exports. Tons.	Retained. Tons.
1913	5,861	517	5,344
1914–15	16,356	327	16,029

Coconut Oil

In discussing the world's trade in copra, the export trade in coconut oil from copra-producing countries should not be overlooked. The amount of coconut oil exported from such countries depends to some extent on the relative prices of copra and coconut oil, the latter being made and exported in preference to copra when the price of the latter in the world's markets is relatively low. In some places, such as Seychelles and Zanzibar, manufacture is carried a step further, and coconut-oil soap is made for export in favourable times. There is, however, at present only an insignificant export of coconut oil from Seychelles and Zanzibar. The exportable surplus of coconut oil available in the tropics[1] in 1912, 1913, 1914 and 1915 has been as follows :

Exports of Coconut Oil from the Principal Tropical producing Countries

	1912. Tons.	1913. Tons.	1914. Tons.	1915. Tons.
Ceylon	20,089	27,349	24,324	25,075
India	4,832	4,591	4,523	10,508
Philippines	½	4,931	11,754	13,251
Australia[2]	5,162	1,977	4,231	—

The following table shows the latest available statistics of imports of coconut oil from all sources into the chief

[1] Australia is included for convenience of discussion.

[2] Oil expressed from imported copra. Up to and including 1913 the Australian trade year was the calendar year; in 1914 it began to date from July 1.

countries importing this oil. Figures for the last three years are not available for many countries:

Imports of Coconut Oil into Chief Importing Countries

	1912. Tons.	1913. Tons.	1914. Tons.	1915. Tons.	1916. Tons.
United Kingdom, unrefined	31,572	31,140	19,879	33,479	21,122
" " refined	30,087	27,337	15,471	16,167	7,747
United States [1]	20,601	22,546	33,208	28,185	29,468
France (metric tons) [2]	3,087	3,924	1,673	426	1,544
Holland	20,028	16,685	—	—	—
Belgium	1,749	1,285	—	—	—
Russia	—	397	—	—	—
Austria-Hungary	6,611	4,895	—	—	—
Germany	333	594	—	—	—

[1] *Returns for years* 1911–12, *etc., ending June* 30 *in each case.*
[2] *Imports of "huile de coco, de touloucouna, d'illippé, et de palmiste."*

To Sweden the following countries exported in 1913 the quantities named: India (1913–14), 494 tons; Ceylon, 170 tons; Germany, 851 tons; Belgium, 30 tons.

To Norway, Ceylon exported 2,031 tons in 1913 and India 12 tons in 1913–14.

The Trade in Copra and Coconut Oil in India

The export trade in copra from India has been steadily expanding in recent years. In 1904–5 the quantity exported was 7,800 tons, valued at £127,000, the average value being 16*s.* 3½*d.* per cwt. In 1913–14 it was 38,192 tons, valued at £1,039,000, the average value being £1 7*s.* 2¾*d.* per cwt. In 1914–15, owing to the war, the exports fell by 6,346 tons, and the average value declined to £1 5*s.* per cwt. During the same period, however, there was an increase of nearly £100,000 in the value of coconut oil exported. The coconut palm grows freely in many parts of India, and there is a large local demand for the oil, which is supplied by village oil-mills. The Malabar coast of the Madras Presidency supplies, however, the bulk of the copra, coconut oil, and other products of the coconut palm which are exported from India. The following table shows the export of the several products of the coconut palm from India to countries overseas for the years 1913–14 and 1914–15:

Exports of Coconut Palm Products from India

		1913-14.		1914-15.	
		Quantity.	Value.	Quantity.	Value.
			£		£
Coconuts	*number*	344,000	1,000	272,000	1,000
Coir fibre	*cwts.*	14,800	11,000	5,000	3,000
Coir manufactures	,,	772,000	592,000	476,000	380,000
Cordage and rope	,,	60,000	70,000	45,000	57,000
Copra	*tons*	38,000	1,039,000	32,000	822,000
Coconut cake (poonac)	*cwts.*	84,000	26,000	67,000	19,000
Coconut oil	*tons*[1]	4,510	155,000	7,540	246,000
Total value			£1,894,000		£1,528,000

[1] *Coconut oil is converted from gallons into tons at the rate of* 242 *gallons* = 1 *ton.*

The following figures show that while the exports of copra from India have advanced, those of coconut oil have declined. The revival of the export of coconut oil in 1914–15 was due to the war.

		1910-11.	1911-12.	1912-13.	1913-14.	1914-15.
Copra	*tons*	22,481	31,876	34,349	38,192	31,845
Coconut oil	,,	7,994	8,955	4,006	4,510	7,540

During the same period Germany's share of the trade was as follows (as shown by the Indian export returns).

		1910-11.	1911-12.	1912-13.	1913-14.	1914-15.
Copra	*tons*	17,428	23,683	27,442	23,989	9,712
Coconut oil	,,	2,935	2,414	677	668	362

Germany was therefore taking more copra and less oil. Before the war Germany also took the bulk of the coconut cake exported from India, on an average about 5,000 tons a year.

The World's Trade in Indian Oil Seeds

The principal data recorded in the Special Section of this article concerning the oil seeds in which India is specially interested are summarised in the table on p. 426. The statistics are for the calendar year 1913, except in the case of India, where they are for the fiscal year ending March 31, 1914.

The figures for the total exports from producing countries are in most cases approximate only, owing to the absence of complete statistics for some of the countries.

THE WORLD'S TRADE IN INDIAN OIL SEEDS, 1913

(n.s.r. = not separately recorded)

Kind of seed.	Total exports from producing countries.	Exports from India 1913–14.		Net imports into chief consuming countries.						
				United Kingdom.	France.	Belgium.	Italy.	Holland.	Germany.	Austria-Hungary.
	Tons.	*Tons.*	*Per cent.*	*Tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*
Cotton seed	858,000	284,000	33	615,000	18,000	n.s.r.	n.s.r.	n.s.r.	219,000	4,000
Linseed	1,808,000	414,000	23	603,000	236,000	197,000	45,000	200,000	560,000	63,000
Niger seed [1]	4,000	4,000	100	350	1,000	20	50	25	2,000	550
Rape seed and mustard seed	385,000	254,000	66	49,000	54,000	37,000	10,000	29,000	161,000	31,000
Poppy seed	2 ,000	19,000	76	n.s.r.	9,000	n.s.r.	n.s.r.	n.s.r.	12,000	3,000
Ground nuts	779,000	360,000 [2]	46	n.s.r.	474,000	n.s.r.	25,000 (ground nuts and sesame seed)	48,000 (ground nuts and sesame seed)	98,000	n.s.r.
Sesame seed	264,000	112,000	42	n.s.r.	20,000	n.s.r.		n.s.r.	116,000	26,000
Castor seed	135,000 [3]	135,000	—	47,000	21,000 [4]	15,000 [4]	11,000	—	10,000 [4]	—
Mowra seed [1]	33,000	33,000	100	—	400	4,500	—	50	23,000	—
Copra [5]	537,000	38,000	7	14,000	112,000	13,000	n.s.r.	18,000	106,000	34,000

[1] *The Trade Returns of the different countries do not show the imports of niger seed and mowra seed separately, and the figures given are the exports recorded in the Indian Trade Returns for* 1913–14.

[2] *Including exports from Pondicherry.*

[3] *Indian exports only.*

[4] *Exports recorded in the Indian Trade Returns for* 1913–14; *the imports of castor seed into these countries are not shown separately in the respective Trade Returns.*

[5] *The net imports into other important consuming countries were as follows: Russia,* 67,000 *tons; United States,* 15,000 *tons; Australia,* 5,000 *tons.*

The net imports into the continental countries represent the imports of "Special Trade," less the exports of "Special Trade," as published in the Trade Returns of the different countries. "Special Trade" is understood to mean, as regards imports, produce imported for home consumption or manufacture, or which has become nationalised by the payment of duty, and as regards exports produce which has been manufactured or in some way improved in the country, or which has been nationalised by the payment of duty. In the case of the United Kingdom, the figures are obtained by subtracting the "Exports of Foreign and Colonial Merchandise" from the total imports given in the Board of Trade Returns.

LIST OF ARTICLES ON OILS, OIL SEEDS AND THEIR PRODUCTS WHICH HAVE APPEARED IN PREVIOUS NUMBERS OF THIS BULLETIN

"The Nature and Commercial Uses of Ben Oil," 1904, **2**, 117.
"The Olive Oil Industry," 1905, **3**, 198.
"The Cultivation and Utilisation of the Soy Bean," 1909, **7**, 308; 1910, **8**, 40.
"The African Palm Oil Industry," 1909, **7**, 357; 1913, **11**, 206; 1917, **15**, 57.
"The Trade in Palm Kernels," 1914, **12**, 458.
"Palm Kernel Cake and Meal," 1914, **12**, 577.
"The Feeding Value of Palm Kernel Cake," 1915, **13**, 446; 1916, **14**, 280.
"Cultivation, Preparation and Utilisation of the Ground Nut," 1910, **8**, 153.
"The Cultivation, Production, Preparation and Utilisation of Castor Seed," 1911, **9**, 17.
"Utilisation of Para Rubber Seed," 1911, **9**, 35; 1913, **11**, 551.
"Cultivation, Production and Utilisation of Sesamum Seed," 1911, **9**, 259.
"Cultivation, Preparation and Production of Linseed," 1911 **9**, 355.
"The Coconut and its Commercial Uses," 1912, **10**, 76, 264.
"The Industrial Position of Copra, Coconut Oil and Coconut Cake," 1914, **12**, 557.

"Cultivation, Preparation and Utilisation of Hemp Seed," 1912, **10**, 94.
"Shea Nuts and Shea Butter," 1912, **10**, 281.
"Perilla Seed and Oil," 1912, **10**, 303.
"The Wood Oil Trees of China and Japan," 1913, **11**, 441.
"The Conversion of Liquid Oils into Solid Fats," 1913, **11**, 660.
"Cohune Nuts," 1914, **12**, 237.
"The Utilisation of Fish and Marine Animals as Sources of Oil," 1914, **12**, 251.
"Illipé Nuts and the Sources of Borneo Tallow," 1915, **13**, 335.
"Production and Utilisation of Rape Seed," 1915, **13**, 452.
"The Sources of Supply of Almonds," 1915, **13**, 460.
"The Cultivation and Utilisation of Sunflower, Niger and Safflower Seed," 1916, **14**, 88.

The results of examination at the Imperial Institute of a great variety of oil seeds from various parts of the British Empire have been published from time to time in this BULLETIN, and those issued up to 1913 were reprinted for the greater part in *Selected Reports from the Scientific and Technical Department, Imperial Institute*, Part V.—*Oil-Seeds, Oils, Fats and Waxes* (*Colonial Reports, Miscellaneous*, No. 88, [Cd. 7260], 1914).

TOBACCO GROWING IN CYPRUS

The following memorandum, prepared by Mr. W. Bevan, Director of Agriculture in Cyprus, has been forwarded to the Imperial Institute by the Government of Cyprus, and is published for general information. It relates solely to Levantine types of tobacco.

THE cultivation of tobacco in Cyprus has been abandoned for many years, during which time great strides have been made in most tobacco-growing countries in the cultivation and preparation of the leaf in order to keep pace with the exacting requirements of the European market.

There are many localities in the Island where tobacco has been grown in old times with more or less success, but whatever art the Cypriot may have attained in the past in the curing and preparation of the leaf has long

since been lost. This circumstance should be borne in mind when considering the possibility of reviving the tobacco industry in Cyprus.

The cultivation of tobacco rapidly declined after the British occupation, and except for a few spasmodic and unsuccessful efforts it has long since been abandoned.

The present shortage of tobacco from Thessaly and elsewhere with consequently high prices has naturally again roused local interest in the cultivation of this crop, and there has been a sudden and remarkable extension in the area sown. Indeed it is said that some 12,000 bales will be produced this year, of which one-third will be fumed or "Latakia" tobacco as compared with nothing up to two or three years ago.

A considerable revenue is derived from the import duty on tobacco, and the fiscal aspect has therefore an important bearing upon the question. Any extension of this crop for local consumption would naturally have an adverse effect upon the revenue, special precautions being taken to prevent illicit consumption.

This objection does not apply to growing tobacco for export, but even this cannot be done without the application of the following, somewhat hampering, regulations, which were first put into force a few years before the British occupation:

The grower has to notify the Customs authorities of his intention to sow, giving the locality and area. Before picking he must also notify the Customs so that a Customs officer may be present at the picking and weigh the freshly picked leaves.

After storing, but before delivering the tobacco to the factory, the Customs officer must again weigh the now dried tobacco leaves.

The Excise duties leviable are:

Tobacco leaf 4½ cp. per oke (about 2*d.* per lb.), payable on transfer of leaf from grower to wholesale dealer.

Tobacco manufactured in Cyprus, whether manufactured into cigarettes or otherwise, in addition to the import duty or transport duty, 3*s.* 6½ cp. per oke (about 1*s.* 8½*d.* per lb.)

These regulations are a relic of Turkish times, as in those days the State received a definite due called "City Toll" by charging the tobacco cutters and tobacco sellers with a trade tax. They appear to have been administered with more laxity in Turkish than in post-occupation times, and it is said that the abandonment of tobacco cultivation was mainly due to the severity with which these rather vexatious and irritating regulations were enforced.

For many years the tobacco imported by local cigarette manufacturers came almost entirely from Macedonia. This tobacco was of very superior quality and cheap, and locally grown tobacco could not compete with it. Of late years the price of Macedonia tobacco has risen considerably, and the manufacturers have therefore been induced to import Thessalian tobacco instead, which is not of so fine a flavour as Macedonian and approximates more closely to Cyprus produce. Cypriot smokers have thus had their palates prepared for the flavour of the locally grown tobacco.

The Agricultural Department has for some three years carried out a series of tobacco cultivation experiments in different parts of the Island, the seed used being Samsoun, Kavallas, Xanthi and Trebizond. In 1915, five samples of the tobacco so grown were submitted to the Imperial Institute, who obtained the opinion of technical and commercial experts upon them. The reports then given were on the whole encouraging, seeing that the samples had had imperfect preparation. The report contains the following passages (cf. this Bulletin, 1915, **13**, 547):

"Samples No. 1 and 2 conform with Turkish tobacco as regards size of leaf, but they contain too much moisture for the English market. . . . The tobacco smokes rather hot, and is only mildly aromatic, but these defects will probably disappear with more experience in the curing of tobacco. The object should be to produce tobacco resembling as closely as possible tobacco of the Turkish Basma type. . . . It would seem desirable to try a number of types of Levantine tobacco with a view to the selection of those best suited to the district."

A tobacco grower from Smyrna is in the employ of the Department who not only superintends the departmental experiments but instructs private growers in the proper methods of cultivation. The Departmental crop of 1915 was sold to a local cigarette manufacturer who reports that: "the tobacco yield of the Island in 1915 was somewhat similar to that imported from abroad; the 1916 yield was better than the previous year, and if the cultivation continues for another two years it is very probable that it will be equal to the imported kinds. There is a much greater inclination towards the native tobacco this year. I could see this very plainly, as I am a vendor of tobacco seed." For a year or two before the war tobacco was grown on a rather extended scale by a Syrian resident near Limassol, and a good number of villagers in different parts of the Island raised plants from seed supplied by him and under contract with him, the produce being locally manufactured into cigarettes which have a fair demand. This tobacco was prepared with no scientific knowledge and with primitive, inadequate accommodation for curing, storing, etc. With more up-to-date equipment a much better tobacco would no doubt result.

The opinion has often been expressed by those competent to judge that the soil in several parts of the Island is well suited to this crop, and the results obtained, where skilled care has been given, seem to endorse this. The fact that the tobacco plant of commerce grows during summer and, if intended for cigarettes, needs no watering after transplanting, is very strongly in its favour. On the other hand it demands much attention and handling, and there is unfortunately a dearth of manual labour, while a capacity for trustworthy, careful attention to details is a rare quality among Cypriot farm hands.

There are many who think it probable that tobacco cultivation in Cyprus has a future and that both as regards quantity and quality Cyprus tobacco may acquire a secure place not only in local but in foreign markets. It is probably too early to speak with any confidence on this point, but it may at least be conceded that Cyprus has provided a smokable tobacco even under rough-and-ready

methods, and that with more highly skilled cultivation and handling an acceptable and merchantable leaf could be produced.

There has this year been undue haste on the part of the cultivators who, with no previous knowledge of the crop and in complete ignorance of the curing operations, have paid high prices for any kind of tobacco seed and have incurred much expense in the vague belief that they have only to pick the leaves as they mature, bale them and convert them into money.

Any such precipitate action is to be deprecated. Experience and skill have yet to be gained, and it should be remembered that the present extremely high prices are unlikely to be indefinitely maintained. The price of tobacco for local consumption will necessarily be regulated by the price of Greek tobacco, and a sudden fall in the latter will cause it to supplant the locally grown leaf.

In 1906, a scheme was under consideration for obtaining British-grown tobacco for blending with American varieties so as to form a mixture for consumption by bluejackets in the British navy. At that time Cyprus was not in a position to participate, but if such an opportunity were now to present itself a portion at least of this year's crop might be so utilised by way of trial.

There has been a good deal of opposition in the past to tobacco growing in Cyprus on the part of local Greek-Cypriot manufacturers, most, perhaps all, of whom owned or had an interest in tobacco fields in Macedonia or Thessaly, and they naturally discouraged any local produce that might compete with their own. The events of the last few years have led to a great change in their attitude, and they are now themselves engaged in growing tobacco here in order to supplement their almost exhausted stocks.

The immediate future of this agricultural industry seems to depend mainly upon the duration and effect of the war. It is reported that a very largely increased area in Thessaly has been sown this year with tobacco and that, if the season is favourable and the labour adequate, there should be a more than usually large crop. If the course of events should allow of this tobacco reaching

the chief markets in Europe, Egypt and elsewhere, then the price will most probably fall to a point that would seriously prejudice the demand for Cyprus tobacco; on the other hand should the Greek crop be cut off from those markets then the immediate local outlook is promising. One thing is certain, that no permanent success can be hoped for unless the growers receive the necessary instruction both in cultivation and curing. Assuming that the present cultivation should prove the soil and climate of Cyprus to be favourable, the Island can only regain its position as a tobacco-growing country when the local growers have acquired the needful experience in the more delicate operations that the market demands.

Latakia Tobacco

The preparation of this special tobacco has been started since the war by Syrian refugees who are said to have been engaged in this particular industry in Syria for many years and to be well acquainted with the work.

For the production of Latakia tobacco the leaves undergo fumigation for four or five months, and a peculiar aroma is thereby imparted which to a considerable extent disguises the natural tobacco flavour. The quality of the tobacco leaf is therefore not of prime importance, and no great care or skill is called for in the matter of fermentation, selection of the leaf and so forth, as in the case of ordinary tobacco. The sale results of the consignments which have been sent to England are believed to have been quite satisfactory. A number of Cypriot farmers have planted tobacco this season, presumably with a view to selling their produce to the Latakia manufacturers and probably in co-operation with them. None of these growers are acquainted with the technicalities of ordinary tobacco cultivation, but it is quite possible that they will be able to produce a leaf which will meet the requirements of the Latakia trade. The conditions for this industry in Cyprus, however, are said to compare unfavourably with those in Syria, where both wood for fumigation and labour are said to be much less expensive. A plant, locally called

"gonisos" (elecampane), which grows wild very plentifully throughout almost the whole Island, is found to be very suitable as an ingredient in the fumigation process.

RAFFIA OR BASS: ITS PRODUCTION, PREPARATION AND UTILISATION

The well-known raffia or bass which is used extensively by gardeners, nurserymen and others as a tying material in grafting and for training plants and attaching them to supports is derived chiefly from the Madagascar palm known as *Raphia pedunculata*, Beauv. (= *R. Ruffia*, Mart.), a species which also occurs in East Africa.

This palm presents a beautiful appearance. Its trunk is from 12 to 24 ft. high, bears numerous leaf-scars, and is surmounted by a magnificent cluster of large pinnate leaves. The leaves sometimes attain a length of 50 ft., and the petiole, from which the leaflets droop gracefully on each side, has a thickness in its middle part of 3 to 4 in. The leaflets are sometimes 5 to 6 ft. long or even more; they have a width of 2 to 3 in. at their widest part and taper towards each end. In the centre of the cluster of leaves arises an elongated cone consisting of the young, unexpanded leaves enclosing the terminal bud.

For satisfactory development the palm requires a moist soil and a humid atmosphere. It is widely distributed in Madagascar, but occurs in greatest abundance along the water-courses and in the marshy valleys. The principal centres of production of the fibre are the Provinces of Majunga, Nossy-Bé and Analalava, and the regions of the east coast between Tamatave and Vatomandry. The palm is essentially a coast species and its vigour diminishes as the altitude increases. It is not found in the south and extreme north of the Island. The preparation of the fibre for export is only carried on near the commercial centres; in the remote regions the natives extract it only for the manufacture of coarse "rabannas" (see page 437) and a closely woven tissue for making mosquito nets.

The raphia palm can be employed for the extraction of fibre when about 15 years old; it reaches its maximum

vigour at an age of about 40 to 50 years, at which time fructification commences. The youngest leaves are collected, one at a time, as they become free from the terminal cone; in order to yield a good product, they should not yet have expanded. At this stage, the leaflets are applied to the leaf petiole, one covering another and forming altogether a cylinder or very elongated cone from 20 to 27 ft. long according to the vigour and age of the palm. Each leaflet is composed of two parts, folded one against the other, and touching one another by the surface which on expansion would become the upper side of the leaflet. These two surfaces in contact with each other are covered with a greenish-yellow epidermis which constitutes the raffia or bass.

Preparation of Raffia

The young leaves are cut from the palms and carried in bundles to the huts or into the village. They are then taken one by one and by means of a small axe the leaflets are cut off near their point of attachment to the midrib. The small leaflets at the extremity of the leaf are rejected.

The two halves of the blade of each leaflet are separated from the midrib by means of a sharp knife. The fibre is then extracted from each half leaflet in the following manner, the whole of this work being performed by women. Each woman sits facing a log of wood and taking one of the half leaflets from the bundle at her side places it on the log so that the middle of the leaf-strip (in respect of its length) is in contact with the wood, the dull or lower surface of the leaflet being uppermost. She then cuts the leaflet transversely with a rather blunt knife held at an acute angle to the surface of the leaf. The knife penetrates the leaflet but does not sever it, as the upper epidermis (in contact with the log of wood) and the layers of thick-walled cells (sclerenchyma) attached to it, being more resistant than the other tissues, are not cut. While holding the knife firmly in the cut thus made, the woman seizes the end of the leaf-strip and pulls it quickly towards her. This action causes the blade of the knife to strip off the soft tissues from that portion of the leaflet which is

furthest from the worker. The woman then takes the knife in the other hand, pulls the other end of the strip towards her, and thus peels off the corresponding part from the other half of it. There now remains a membranous strip which consists only of the epidermis of the young leaflet and the sclerenchyma adhering to it. This, as already explained, is the raffia fibre.

According to another observer, a different method of extraction is sometimes practised. In this case, the half leaflet is cut with a knife across the dull or lower surface at a point about an inch from the base. The layer of tissue is raised up and loosened with the knife, and being then grasped between the thumb and the point of the knife is stripped off at one pull and thus separated from the upper epidermal layer. A somewhat similar method is said to be adopted by the natives of the Belgian Congo.

The long, narrow epidermal strips thus obtained are placed in small heaps or thin layers to dry in the sunshine. In fine weather, the drying is complete in half a day; the more rapid the drying, the better is the result obtained. The green colour of the strips changes, on drying, to very pale yellow or nearly white.

The dry strips are collected into small bundles and tied firmly together at the ends corresponding with the base of the leaflet; each bundle is twisted up into a hank about two inches in diameter. About five or six of these hanks are rolled one on another to form a bundle weighing about 13 to 14 lb. The bundles are then packed into bales, each weighing about 2 cwts.

Yield of Fibre

It has been estimated that the fresh green leaves yield 3·22 per cent. of their weight of commercial raffia or, in other words, one ton of the leaves furnishes about 72 lb. of fibre.

On the average, a raphia palm which has reached the age at which leaves can be cut from it, gives about ten leaves a year. In practice, however, some leaves are always left on the tree to develop, so that, as a rule, six leaves may be regarded as the annual output of any one

tree. As six fresh leaves weigh about 225 lb. and the yield of dry raffia is 3·22 per cent., the average yield per tree is about 7¼ lb. per annum.

Raffia Trade of Madagascar

Although raffia has been used by the natives of Madagascar from the earliest times for the manufacture of rabannas and for various other purposes, the fibre was not exported from the Island until about 1866. At first the exports consisted only of cheap rabannas; these are strips of coarsely woven raffia matting and were used in Mauritius and Réunion in the process of drying sugar and for baling purposes. Raffia was not known on the European market until 1875. The price was then about £12 per metric ton; it gradually rose, but towards 1878 diminished to some extent owing to an accumulation of stocks on the market. When the stocks had been disposed of, the price rose continuously as the uses of the product were multiplied and the consumption consequently increased. Raffia is now exported from Madagascar in large quantities, especially from the ports of Fenoarivo, Tamatave, Vatomandry and Majunga. Before the war the price at Tamatave varied from £18 to £24 per metric ton for the best qualities.

The quantities and values of the exports of raffia fibre from Madagascar in 1913 and 1914 are shown in the following table:

Exports of Raffia from Madagascar

Destination.	1913		1914	
	Metric tons.	£	*Metric tons.*	£
France	3,564	80,636	2,869	63,129
United Kingdom	331	8,491	269	5,910
Germany	1,824	41,773	1,067	23,465
Other Countries	242	6,148	219	4,825
Total	5,961	137,048	4,424	97,329

The annual imports of raffia into the United Kingdom prior to the outbreak of war probably varied between 300 and 450 tons per annum, but no accurate statistics are available. The material was at that time quoted in the London market at prices ranging from £25 to £35 per ton, according to quality.

Raffia cloth is exported from Tamatave in pieces from 9 to 10 ft. long and from 24 to 26 in. wide. These "rabannas" are usually packed to the number of 300 in a bale. In January 1917, the value of the rabannas in London was about 1*s.* 2*d.* to 1*s.* 3*d.* each.

Characters of Raffia

Raffia comes into commerce in the form of long narrow strips, varying from ¼ in. to ¾ in. in width and from 2½ to 5 ft. in length. It is usually straw-coloured or pale yellow and sometimes has a greenish tint. The poorer qualities, however, have a yellowish-brown colour. The commercial value of the product depends greatly on its appearance and colour. The strips should be of good length and strength and as wide as possible, and should be flat instead of, as is sometimes the case, being rolled up from the edges. Narrow, stringy material is objectionable and its presence considerably reduces the value of the fibre.

The raffia strip consists of the leaf epidermis, which is strongly thickened on the exterior, and bands of sclerenchymatous cells immediately beneath it. In the case of Madagascar raffia (*Raphia pedunculata*) these bands of sclerenchyma are separated from one another by only one, or rarely two thin-walled parenchymatous cells.

West African Raffia

Certain other species of Raphia yield a fibre analogous to that of *R. pedunculata*, but generally of a somewhat poorer quality. Of these the most important is *R. vinifera*, Beauv. (= *R. taedigera*, Mart.), which is abundant in many parts of West Africa.

The inferiority of West African raffia to that of Madagascar is said to be partly due to anatomical differences. It has been found that similar bands of sclerenchyma occur beneath the epidermis of *R. vinifera* leaves, but that they are not so near to one another as in the case of *R. pedunculata*, and are separated by at least two or three thin-walled parenchymatous cells. Moreover, the bands are not so thick as those of *R. pedunculata*, and only one or

two cells of each adhere directly to the epidermis. For these reasons, West African raffia is liable to be weaker than the Madagascar variety, but is more easily prepared.

It has been stated that in some parts of West Africa the raffia is obtained from the older leaves which are already beginning to wither. Since, as the leaves dry, the bands of sclerenchyma do not shrink to the same degree as the thin-walled tissue beneath them, these bands, together with the epidermis, become detached from the rest of the leaf tissue and can be peeled off easily from almost the whole length of the leaflet. Such raffia would naturally be darker in colour and inferior in quality to the product obtained from the young leaves.

Raphia palms are abundant in the Belgian Congo, especially along the course of the river and its tributaries and in marshy valleys. Several species of the palm occur—viz. *R. Laurentii*, Wildem., *R. Gentilii*, Wildem., *R. Munbuttorum*, Drude, *R. Sese*, Wildem., and *R. vinifera*, Beauv.; the first of these gives the longest and most resistant fibre. It is stated that in this country, as in Madagascar, the raffia is prepared from the young, unexpanded leaves.

In the Ivory Coast, raffia is obtained from the leaves of *R. longiflora*, Mann and Wendl., which is said to yield a product of as great a length as that produced in Madagascar.

Consignments of raffia have recently arrived in England from the Belgian Congo and from Togo and, although inferior to the Madagascar product, are regarded as of promising quality.

East African Raffia

As has already been stated at the commencement of this article, *Raphia pedunculata* occurs in certain parts of East Africa. A sample of raffia fibre from Taveta, British East Africa, was received at the Imperial Institute in 1905. It consisted of pale brown ribbons about 4 ft. to 5 ft. 6 in. in length and of good strength and medium width. It was regarded at that time as worth £28 10*s*. to £29 per ton, but if of better colour would probably have been of a value 20*s*. to 30*s*. in advance of this price.

Utilisation of Raffia

Raffia is used by the natives of the countries in which the palms occur for many purposes, including the preparation of comparatively fine threads for weaving into fabrics which are composed either of raffia alone or of a combination of this fibre with cotton or silk. Reference has already been made (page 437) to the rabannas of Madagascar, which are not only employed locally but also form an article of export. The fibre is also used in Madagascar for making garden hats for export to France. In Zanzibar, raffia is manufactured into sacks for packing various products for export.

In Europe, the fibre is chiefly employed for the agricultural and horticultural purposes already mentioned. It is stated that in France it is utilised for the manufacture of mats, carpets, baskets, curtains, etc. Raffia can be readily dyed, and the dyed strips can be plaited or woven into various small useful articles. Such work is now being taught to the children in many schools, and the use of the fibre in this direction appears to be extending. It is stated that similar work has been introduced in certain hospitals with the object of assisting patients to recover the use of their fingers.

It is probable that after the war a large demand for raffia for horticultural and similar purposes will arise in Australia, Canada, the United States and many other countries.

It appears, therefore, that there may be a good opportunity for the development of a raffia industry in West Africa and possibly also in parts of East Africa. It must be borne in mind, however, that it is very desirable that the preparation of the fibre for export should be carefully carried out, as the value of the material depends so largely on its colour, length and general appearance. There is little doubt that the exercise of special care in preparing, drying and packing the fibre for the market would be well repaid by the higher prices obtainable for the product.

NOTES

The Trade and Industries of Seychelles.—The Colonial Office has sanctioned the publication of the following particulars taken from the Report of the Collector of Customs on the Trade of Seychelles for 1916:

The total trade of the colony for the year shows an increase of Rs. 641,206, as compared with the figures for the previous year. The total value of the imports in 1916 was Rs. 1,486,420, showing an increase of Rs. 378,930 over the previous year. The principal items in which there was an increase, compared with the figures for 1915, were the following: Foodstuffs, Rs. 635,471, including rice from India to the value of Rs. 336,235; cotton goods, Rs. 389,122, mainly from India (Rs. 328,943), United Kingdom and France; haberdashery, Rs. 55,988; kerosene oil, Rs. 13,787, chiefly from the United States of America and Dutch Colonies; sugar, 301,538 kilograms (230,283 kilograms from Mauritius).

The following items of imports showed a decrease in comparison with figures for the previous year: Coal, 24 tons, from South Africa; machinery, Rs. 5,441; benzine and engine oil, Rs. 2,505; wines, spirits and beers, Rs. 56,285; tobacco, cigars, cigarettes and snuff, Rs. 8,467, chiefly from French Colonies, United Kingdom, Holland and Egypt.

The total value of exports in 1916 amounted to Rs. 1,672,242, showing an increase of Rs. 262,276, as compared with the previous year. The following table shows the values of the chief local products exported in 1916 in comparison with the exports of 1915:

	1916	Comparison with 1915 figures.		Chief destinations.
	Rupees.	Increase of.	Decrease of.	
Copra	836,829	—	57,420	France, South Africa.
Coconuts	4,300	—	5,293	Mauritius, Aden.
Coconut oil	28,210	—	1,552	French Colonies, Aden, Mauritius.
Guano	29,400	—	29,400	Mauritius.
Vanilla	164,069	137,824	—	United Kingdom, France.
Caret shells	16,225	2,398	—	France, United Kingdom.
Cinnamon bark	12,359	—	3,239	United Kingdom, Switzerland.
Soap	39,523	8,238	—	French Colonies.
Essential oils	94,200	52,085	—	United Kingdom, France.
Whale oil	2[illegible],000	—	82,636	South Africa.
Rubber	6,746	5,606	—	United Kingdom
Calipee	4,623	—	2,295	United Kingdom.
Hides	1,240	40	—	United Kingdom.
Salted fish	9,626	1,271	—	French Colonies, Mauritius.
Coco-de-mer	457	—	4,240	Singapore.

The main cause of the heavy decrease in the exports of the products of the coconut palm was the shortage of shipping. In order to improve the financial position of the

Colony, an export duty was put on coconuts, coconut oil, copra and soap.

The decrease in the export of guano is due to the fact that the trade with Europe, the chief destination of this produce, has been totally suspended since the outbreak of war. There was a considerable increase in the trade in vanilla, 20,491 kilograms being exported, which is the highest figure recorded since 1910, when the export of vanilla amounted to 26,353 kilograms. The essential oil industry still shows an increase in production. There were eighteen oil-distilling plants at work in the Colony in 1916.

The falling off in the export of coco-de-mer is due to want of steamer cummunication from Seychelles to Bombay.

Sisal Hemp Machinery.—In an article on Sisal hemp (this BULLETIN, 1915, **13**, 430), an account has been given of the machinery used for the extraction of this fibre. In addition to the machines described in that article, reference may be made to machinery manufactured by Messrs. David Bridge & Co., Ltd., Castleton, Manchester, which was invented by Mr. F. A. G. Pape, who has had considerable experience in the preparation of Sisal hemp and similar fibres.

Before being introduced into the decorticator, the leaves are treated by a crushing machine, termed the "Acme Gravity Leaf-crushing Machine," which consists essentially of two pairs of rollers. The leaves enter the crusher over a revolving feed-table of calculated speed. They are then squeezed between the corrugated front rollers and are flattened to within the clearance left of $\frac{1}{4}$ in. The rear rollers reduce them still further to $\frac{3}{16}$ in. The machine is designed to deliver the crushed leaves at the revolving feed-table of the decorticator.

The scutching machine or "Climax Patent Sisal Decorticator," like most of the machines described previously, is constructed on the raspador principle, and consists of opposed drums with automatic feeding and conveyor parts. Various improvements have been introduced in the construction of this decorticator with the objects of facilitating working, ensuring smooth running, preventing clogging, and obviating any damage to the fibre. One advantage claimed for the machine is that it does not involve any outlay on steel or heavy masonry buildings, since all heavy overhead transmissions have been eliminated.

The decorticator, when working in conjunction with the leaf-crushing machine, is capable of treating about 100,000 leaves per day of ten hours. The driving power required is 10 b.h.p. for the crusher and 18 b.h.p. for the decorticator. The services of three men are required for the crusher and those of four men for the decorticator.

Smaller single-drum machines have been devised by

the same firm for the preparation of samples and for experimental work, and these should be particularly useful in connection with the preliminary trial cultivations that are necessary before fibre cultivation on a large scale can be undertaken in new territory.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs

Coffee.—It is stated in the *Journ. Bd. Agric., British Guiana* (1917, **10**, 83) that the coffee industry of British Guiana continues to extend, the areas under cultivation in recent years being as follows: 1905, 1,432 acres; 1910, 2,546 acres; 1915, 4,468 acres. The Liberian variety is chiefly planted as it gives good returns and costs less to cultivate than the Arabian variety. Most of the coffee produced in the Colony is consumed locally, only a small proportion being exported.

Pecan Nuts.—In this Bulletin (1910, **8**, 405) an account was given of the pecan nut (*Carya olivaeformis*) and its cultivation in the United States. A memorandum on the progress and present position of the pecan nut industry, prepared recently by the Bureau of Plant Industry of the United States Department of Agriculture, has been published in the *American Nut Journal* (1917, **6**, 20). A few fairly large orchards were planted about 1885, but there was little extensive planting before the beginning of the present century, whilst most of the large orchards have been established since 1905. It is considered probable that the rapid progress of the industry was due to improvement of machinery for cracking the nuts. Several different types of machine are now in use which are capable of cracking from 600 to 800 lb. of nuts daily in such a manner that about 75 per cent. of the kernels can be separated from the shells as unbroken halves. In the planted orchards, young trees, 8–10 years old, are yielding under favourable conditions an average of 2–3 lb. of nuts per tree, whilst under the best conditions they sometimes produce 12–15 lb. per tree. The average number of trees in the orchards already planted is 20 per acre. Although the orchards now in bearing probably do not represent more than two-fifths of

the total, the production in 1915 was estimated at 750,000 lb. and that in 1916 at about the same figure. In the Albany district of south-west Georgia, which is one of the largest pecan-growing regions, there are several miles of large orchards on each side of the railway. In view of the rapidly increasing importance of the industry, careful consideration is being devoted to it by the United States Department of Agriculture.

Sugar.—In the *Board of Trade Journ.* (1917, 98, 105) reference is made to an account of the sugar industry of Natal given in the Second Interim Report of the Union Government's Advisory Committee on the Control of Food Supplies and other Necessaries. The industry was commenced about eighteen years ago, when the Uba cane was introduced, and it succeeded so well that in 1904–5, 30,000 tons of sugar-cane were produced. After the opening of the Zululand coast-belt, the industry underwent rapid expansion, and 50,400 tons of cane were produced in the 1909–10 season. During more recent years, the output has been as follows: 1913–14, 91,766 tons; 1914–15, 98,371 tons; 1915–16, 115,481 tons; and 1916–17, 114,504 tons. More than 400 planters are now growing the crop. The sugar-mills and refineries are experiencing considerable difficulty at the present time owing to the restriction in the supplies of chemicals and their increased prices, as well as to the fact that the replacement and renewal of plant and machinery are almost impossible.

A review of the sugar-growing industry of India is given in the *Report on the Progress of Agriculture in India for* 1915–16. The area under cultivation has been reduced considerably during recent years on account of the importation into India of sugar from Java, which has increased in twenty-five years from 70,000 tons to more than 800,000 tons. The Agricultural Departments are therefore endeavouring to increase the production with a view to rendering the country independent of external supplies. The industry has been stimulated by the prevailing high prices of sugar and in 1915–16, 2,375,000 acres were devoted to the crop. Efforts are being made to increase the yield per acre, which is low compared with that obtained in other countries, by the introduction of improved varieties and better methods of cultivation.

In the United Provinces, a definite advance has been made by the demonstration of the suitability of a cane of medium thickness which is capable of giving much higher yields than the indigenous cane. During 1915–16, this variety gave 600–700 maunds (22–26 tons) of cane per acre as compared with the average return of 200–300 maunds (7–11 tons) per acre from the ordinary variety grown by the local cultivators.

Good progress has been made in Bombay, especially on

the new Godavari Canals where sugar-growing is extending rapidly. Encouraging results were obtained at the Manjri Farm, where the best sugar-cane crop amounted to over 50 tons of stripped cane per acre, yielding 13,362 lb. of gur.

In the Central Provinces the area under sugar-cane has decreased during the last thirty years from 42,000 acres to 17,000 acres, but it is hoped that the industry will soon regain its earlier position owing to the opening of large areas under the new irrigation works. The local canes are being replaced by superior varieties introduced by the Department of Agriculture.

In Burma sugar-growing is at present in the experimental stage, but the prospects are very favourable. Excellent conditions prevail in the Môn Canal area, where a yield of 30 tons of cane per acre has been obtained at an experiment station.

In Assam there are some large tracts of waste land which may prove to be suitable for sugar-growing and for the establishment of central factories, and the local Department of Agriculture has undertaken a study of the possibilities in this direction. A report on the subject has been published in the *Indian Trade Journ.* (1917, **45**, 70). In 1913 a Government Sugar-cane Farm was established at Khagrabari, near Nalbari, in the Kamrup district, as it was considered that the soil in North Kamrup was suitable for sugar-cane growing on a large scale, and that if the preliminary experiments were successful a large sugar industry might eventually be created in the Province. In 1916, nearly 300 acres of sugar-cane of excellent quality were in full bearing on the Farm. The crop has now been cut and has yielded over 20 tons of cane per acre, which furnished 15 per cent. of sugar. This trial has proved that the best sugar-cane can be grown in Assam on a commercial scale and with a minimum of labour by the use of steam-cultivating machinery. There is a large area of land in the neighbourhood of the Government Farm which is well adapted to the crop and will be leased to those desiring to start factories.

In an account of the crops grown in the Experimental Fields in British Guiana (*Journ. Bd. Agric., British Guiana*, 1917, **10**, 62) it is stated that the total area devoted to the sugar-cane in the Colony in 1916 was 75,744 acres, or 2,636 acres more than in the previous year. A noteworthy feature of the industry is the gradual replacement of the Bourbon cane by new varieties raised from seed. The percentages of the total area occupied in 1916 by the various sugar-canes according to their origin were as follows: Bourbon and other old varieties, 17·22; Java, 0·25; Barbados, 9·20; British Guiana, 73·33. The exports of sugar in 1915 amounted to 116,223 tons, an increase of 9,086 tons over those of the previous year. No molasses was exported, as

most of it was used in the preparation of rum, of which 4,698,230 proof gallons were exported, or 1,209,551 gallons more than in 1914. The exports of molascuit were 2,233 tons, or 193 tons less than in 1914. The results of the experimental work on sugar-cane were satisfactory, and the quality of the seedlings examined for the first time in 1915 was far higher than during many previous years.

OILS AND OIL SEEDS.

Coconuts.—In Malacca, pupæ of the red-coconut weevil (*Rhynchophorus ferrugineus*) have been found to contain a pupating parasite, which has been identified as a wasp, *Scolia erratica*, Smith. In view of the possible value of the parasite in keeping the coconut weevil in check, it is recommended that a study should be made of its life-history (*Gardens Bulletin, Straits Settlements*, 1917, **1**, 399).

Cotton Seed.—An article by Vakil in the *Journ. Soc. Chem. Indust.* (1917, **36**, 685) deals with the manufacture and uses of cotton-seed oil, oil-cake and other products, with special reference to Indian cotton seed. The amount of cotton seed produced annually in India alone is estimated to be nearly 1,870,000 tons[1]; of this quantity about 190,000 tons are required for agricultural purposes, and as less than 300,000 tons of seed have been exported annually during recent years, it is evident that enormous quantities are wasted, even if allowance is made for local production of oil.

The author points out certain important differences between Indian cotton-seed oil and the oils derived from American and Egyptian seed, among which may be mentioned the larger amounts of free fatty acid, colouring and albuminous matter in the crude oil from Indian seed, which cause greater loss in refining the oil. Indian cotton-seed oil is also stated to contain less "stearin," and to be rather less suitable for the manufacture of margarine. Further, it is said to possess an unpleasant "fishy" odour and a bluish-green fluorescence, which are very difficult to remove, although edible oil can be and is prepared from Indian cotton-seed oil.

The author found that cotton seed from different districts in India contained from about 18 to nearly 23 per cent. of oil, and he considers that the percentage of oil is capable of being raised by co-operative action between the Departments of Agriculture, farmers and ginners. The author states that at present Indian cotton seed is valued in the United Kingdom on the basis of a yield of 18 per cent. of oil, and the poor reputation of Indian seed is traceable to adulteration of the seed in India with foreign matter up to the limit required by contract.

[1] The production in India in 1913–14 was 2,120,000 tons (see p. 363).

With regard to by-products, Vakil states that the hulls have been largely used in India in the government dairies and on farms for feeding cattle, while the army transport and commissariat departments in India have also used the hulls in large quantities with excellent results.

Ground Nuts.—Manuring experiments at the Ranchi Government farm, Chota Nagpur, with lime, bonemeal, sulphur and gypsum, alone or in admixture, showed that these materials were all beneficial to the growth of ground nuts (*Agric. Journ. Bihar and Orissa*, 1916, **4**, 1). The addition of comparatively small amounts of sulphur or of gypsum to manures caused the plants to grow luxuriantly and improved the yield of nuts considerably.

The soil in the Ranchi district appears to owe its comparative barrenness to a deficiency in sulphates, but there appears to be no difficulty in remedying this, as gypsum can be obtained cheaply from Rajputana. A number of varieties of ground nuts were experimented with, but they exhibited no marked differences in yield. If ground nuts can be established as a staple crop in Chota Nagpur it is considered that the difficulty of enriching the soil with nitrogen will be solved, whilst at the same time the danger at present experienced in the district of relying on a single crop—rice—will be avoided.

Rubber

Hevea.—The results of tapping experiments carried out at Gunong Angsi are recorded by Spring and Bunting in *Agric. Bulletin, F.M.S.* (1917, **5**, 111). The experiments were made to ascertain the relative yields of rubber from adjacent and opposite quarters by daily and alternate-day tapping, both systems being compared on a two- and four-year renewal of bark. The trees used were six years old at the commencement of the experiments, which were made on two areas, one at an elevation of 300 ft. with 76 trees per acre, the other at 1,200 feet with 193 trees per acre. The results obtained indicate that (1) the yield of rubber from adjacent quarters (double V) is greater by about 18 per cent. than from opposite quarters; (2) the percentage of No. 1 latex is somewhat higher (3 to 6 per cent.) from adjacent quarters, than from opposite quarters where the conditions tend towards a greater production of scrap; (3) the tapping of opposite quarters appears to be more exhausting to the tree than the tapping of adjacent quarters, as daily tapping on the latter system gave 26 per cent. more rubber than opposite quarters; (4) opposite-quarter tapping not only gives lower yields and more scrap than adjacent quarters, but also necessitates the use of two cups and spouts and is more laborious; (5) results previously published have shown the superiority of adjacent-quarter

tapping on virgin bark, and the experiments under discussion show this to be the case also with renewed bark.

The yields obtained on a number of rubber estates in Malaya during 1916 were unusually good (*India Rubber Journ.*, 1917, **53**, 758). In several cases they exceeded 400 lb. of rubber per acre, and a yield of 519 lb. was obtained in one case. The latter is not a record, however, as in 1906 one plantation of old trees yielded 600 lb., and another of ten-year-old trees yielded 554 lb. per acre.

Investigations on the mode of occurrence of latex vessels in *Hevea brasiliensis* by Bryce and Campbell (*Bulletin* No. 30, 1917, *Dept. Agric., Ceylon*) indicate, among other points of interest, that there is a diminution in the production of latex vessels in February and March during the leaf change, and that the number of rows of latex vessels in the cortex decreases with the height above the ground. The latex vessels generally run in a parallel direction, and no well-defined cases of connection between adjacent vessels were noticed, although bifurcation of the vessels was observed in some cases.

Bulletin No. 22, 1915, *Dept. Agric., Ceylon*, gives a full account of researches in Ceylon by L. E. Campbell on the seasonal variations in the storage of plant food in *Hevea brasiliensis* and their relation to resting periods. The results of earlier experiments published in *Bulletin* No. 16 (1915), and referred to already in this BULLETIN (1915, **13**, 485), indicated that there was no great variation in the amount of starch stored in the bark or wood from November till the time of leaf-fall in March; further, no diminution in starch was evident when the trees were leafless, but a large amount of starch was withdrawn from the bark when the leaves were attaining their full size, while starch was also withdrawn from the wood at the same time. Recovery of reserve starch began to occur three weeks after the leaves were fully formed in April and continued until June. Enquiries were made as to the usual period during which tapping is discontinued on estates in various parts of the island; the usual procedure is to cease tapping at some period whilst the trees are changing foliage, and to discontinue tapping from the time the old leaves fall until the new leaves are almost fully grown; the resting period generally lasts for from four to six weeks. The results of the author's researches indicate that the resting period should last from the time the new leaves are developing until about three weeks after their full development, and may advantageously be extended from the time of leaf-fall until a month or more after the trees have regained their full foliage.

The formation of nodules or burrs in the cortex of Hevea trees has been investigated by Bryce (*Bulletin*

No. 28, 1916, *Dept. Agric., Ceylon*), who concludes that these are not produced by the attack of parasitic organisms and are not infectious, but are "the result of an alteration in the latex vessel content." Several different forms of nodule can be distinguished, and certain individual trees exhibit a tendency to form nodules more readily than others, while tapping appears to induce the formation of nodules in trees predisposed to form them.

A process for the spontaneous coagulation of latex without the addition of preservatives or added coagulants, and air-tight apparatus allowing the escape of the gases evolved, has been patented by Thomas and Maude (*India Rubber Journ.*, 1917, **53**, 495).

In a paper in the *Agric. Bulletin, F.M.S.* (1917, **5**, 183), Eaton discusses the advisability of preparing rubber in "slab" form in preference to sheet or crêpe. He calls attention to the excellent quality of rubber prepared from "slab" (*i.e.* coagulum allowed to remain in a moist condition after coagulation) and asserts that it is remarkably uniform in rate of cure. It can be shipped either as rough slab, as crêpe, or in block form. The author favours shipment as rough slab or in block form, and mentions that a large American firm supplies its factories with rough slab packed in bags, and that the firm is apparently satisfied with the quality of such rubber.

Experiments carried out by Eaton (*Agric. Bulletin, F.M.S.*, 1917, **5**, 177) show that rubber found to be attacked by "spot disease" on reaching its destination in Europe or elsewhere may have been quite free from the disease when it left the factory in the East, and that the disease is almost certainly caused by the rubber having been accidentally wetted—*e.g.* by sea water—while being carried in barges or boats to the vessel. Dry clean crêpe rubber was dipped in water for a few minutes, and, after shaking to remove surface water, was rolled up; on keeping for a few days a considerable development of chromogenic organisms took place, causing orange, blue and yellow spots. Sheet rubber and "slab" were not attacked when treated in the same way, though chromogenic organisms developed on the surface of both these rubbers when they were cut open. Air appears to be necessary for the growth of the organisms, and an excess of water hinders their growth. It seems probable that the organisms attack the proteins or their decomposition products.

According to Pratt (*Agric. Bulletin, F.M.S.*, 1917, **5**, 180) "black thread" disease (*Phytophthora Faberi*) is particularly favoured by the following conditions: 1. Wet weather; light rains with an overcast sky form ideal conditions, while the disease ceases in dry weather. 2. Badly drained flat land. 3. Dense shade in thickly planted areas. 4. The height of the tapping cut from the ground; cuts above

20 in. from the ground are less affected than those below this height in Sumatra. The results of experiments on a considerable number of trees show that treatment of the tapping area with a disinfectant every day at the time of collection of the latex serves to control the disease although it does not eradicate it. Carbolineum appears to be the most satisfactory disinfectant, but Izal (10 per cent. solution) is also good and is being used on an area of 24,000 acres. The disinfectant is applied to the cut by means of a brush conveniently made of a piece of rattan cane crushed at the end; the process only entails about half an hour's extra work in tapping 600 trees when the coolies become accustomed to the work.

Manihot Glaziovii.—A good deal of controversy has taken place in the past as to the relative merits of the two different types of trees of *M. Glaziovii.* The results of experiments by Nélis in the Belgian Congo (*Bulletin Agric. Congo Belge*, 1916, **7**, 240) show that the spreading (or "weeping") type of tree is superior to the erect (or "candelabre") type. The spreading type is more resistant to wind and yields more rubber than the erect type, while the quality of the rubber is in no way inferior. The spreading variety is therefore to be recommended for planting in preference to the erect variety if the varieties prove to be fixed, on which point experiments are being made.

Miscellaneous.—Peachey has contributed a paper to the literature of rubber vulcanisation (*Journ. Soc. Chem. Indust.*, 1917, **36**, 424) entitled "Catalytic Acceleration of the Vulcanising Process." The author discusses briefly the various German patents claiming a large number of organic bases as accelerating agents, and describes the action and methods of using *p*-nitrosodimethylaniline, which is now being manufactured (under *Eng. Pat.* 4263 of 1914) in the United Kingdom and sold under the name "Accelerene." The addition of 0·5 per cent. of this substance to the mixing reduces the time of cure to about one-third of the normal. In the presence of magnesia the effect is even more pronounced, but litharge (itself an accelerator) reduces the activity of the substance. The use of this accelerator is likely to prove valuable in the manufacture of rubber goods, especially vulcanite, where a long period of cure is necessary under normal conditions, while the use of "accelerene" in presence of only a small excess of sulphur is also claimed to obviate the fault known as "blooming" or "sulphuring up" caused by the crystallisation of free sulphur on the surface of vulcanised rubber on keeping.

Rubber Bark Rot in Ceylon.—With reference to the note on bark rot disease of rubber in the Kalutara district of Ceylon, published in this Bulletin (1916, **14**, 633) on the

authority of an article in the *Ceylon Observer*, the Director of Agriculture in Ceylon has informed the Imperial Institute that, although a bark-rot disease is found in several localities in the island, no such disease as that described in the *Ceylon Observer* occurs there, and the suggestion of wholesale disease in the Kalutara district has been repudiated by the planters.

FIBRES

Flax.—In accordance with the resolution passed by the Dominion Parliament of Canada in 1916 with reference to the flax industry of that country (this BULLETIN, 1916, **14**, 299), considerable attention has been devoted recently to this subject, and a flax mill is being erected at the Experimental Farm at Ottawa (*Agric. Gazette of Canada*, 1917, **4**, 253). The mill is being equipped with modern machinery, and provision is being made for the installation of new machinery in order to determine the efficiency and economy of the latest inventions. The mill is provided with three retting tanks, each having a different system of heating and water circulation. Drying chambers are also provided in order to ascertain whether artificial drying can satisfactorily replace the expensive system of drying in the field. The mill is being furnished with everything necessary for conducting exhaustive experimental work in fibre production. Trials on the cultivation of the crop are to be conducted on the Central Experimental Farm and on Branch Farms, as well as in various promising districts of the country. The experiments will be directed to the determination of (1) the areas suitable for flax production, (2) the best quantity of seed to sow per acre, (3) the most suitable time for sowing and harvesting the crop, (4) the extent to which flax reduces the fertility of the soil, and (5) the most satisfactory manures to apply to the soil. During the last season, plots of one acre each were grown in various parts of Canada and, on the whole, it appears that excellent fibre can be produced in many sections of the Dominion, and especially in the Maritime Provinces, Quebec, Ontario, and British Columbia. Investigations are in progress with regard to the possibility of utilising linseed straw for the manufacture of upholstery tow, fibre board and paper.

Sisal Hemp.—The Sisal hemp industry of the East Africa Protectorate makes steady progress. According to *Colonial Reports—Annual*, No. 921, *East Africa Protectorate* [Cd. 8434-8], the exports in the year 1915-16 amounted to 46,407 cwts. of value £74,669, of which 97½ per cent. was consigned to the United Kingdom. It is anticipated that Sisal hemp will soon become the principal article of export from the Protectorate.

According to *U.S. Commerce Reports* (1917, No. 45, p. 726) the production of Sisal hemp in the Hawaiian

Islands is almost entirely confined to the island of Oahu, where about 1,800 acres are under cultivation. In 1916, nearly 1,000 bales, weighing 650–700 lb. each, were exported, the greater part of which was sold in San Francisco at about 6½*d*.–7*d*. per lb. The area devoted to Sisal hemp is gradually extending in Oahu, and there is much land suitable for the crop in other islands of the group.

It is stated in the *Bulletin Pan-American Union* (April, 1917, 527) that a fibre-stripping machine is being installed in Bolivia for the purpose of conducting experiments in certain regions where large areas of agave exist. The machine will be used first at Miguella, where a Government Agricultural Experimental Station was recently established. If the experiment proves successful, the industry may grow to large proportions.

Cotton

Reference has been made in this BULLETIN (1913, **11**, 354; 1914, **12**, 312; 1917, **15**, 285) to the damage which has been caused to the Egyptian cotton crop in recent years by the pink boll-worm (*Gelechia gossypiella*, Meyrick, = *Pectinophora gossypiella*, Saunders). A full account of this insect, including its distribution, anatomy, life-history, habits, food-plants, parasitic and other natural enemies, has been given by August Busck, Entomological Assistant, Bureau of Entomology, U.S. Dept. Agric., in the *Journ. Agric. Research* (1917, **9**, 343). This pest is one of the most destructive cotton insects known; it reduces the yield of cotton by 50 per cent. or more, and also diminishes the quantity of oil obtainable from the seeds. It has caused such havoc in the Hawaiian Islands that cotton growing has been almost entirely abandoned. During the last few years, the insect has been introduced into Mexico and Brazil through cotton seed imported from Egypt, and has become established in important cotton areas of both these countries. In 1916 the pest caused a loss of 50 per cent. of the crop in some parts of Brazil and will probably continue to reduce materially the profits of the industry in spite of any measures which may be taken to control its ravages. The pink boll-worm has also become a serious pest in the Laguna district of Mexico near San Pedro, and its presence there constitutes a grave menace to the cotton fields of the United States. At the present time the United States is practically the only large cotton-growing country which is free from the pest, and every effort is being made to prevent its introduction. Regulations have been made by the Federal Horticultural Board to enforce the fumigation of all foreign cotton imported.

The same paper contains a similar descriptive and anatomical study of another lepidopterous insect, *Pyroderces rileyi*, Walsingham, which is known as the "scavenger

boll-worm," as it frequently occurs in decayed bolls injured by other insects. This insect is often mistaken for the pink boll-worm, but the anatomical details now provided enable the two to be readily distinguished.

Union of South Africa.—In the *African World* (1917, 59, 93) reference is made to the possibilities of cotton cultivation as a large industry for South Africa. It is pointed out that the best results have been obtained in the warmer parts of the Transvaal, Natal, Eastern Province, Transkei, Zululand and Swaziland, the principal centre being the Rustenburg district. In this and the Zoutpansberg areas, about 6,000 acres are now devoted to cotton. Last season 500,000 lb. of seed-cotton were produced within the Union, and it is estimated that the present crop will amount to 3,000,000 lb. of seed-cotton, yielding 1,000,000 lb. of fibre. The type of cotton chiefly grown is American Upland, and the crop usually realises good prices. It is considered that, in general, the conditions are favourable, and that with intelligent co-operation of the farmers and perhaps with the aid of Government ginneries, a large and remunerative industry could be established.

West Indies.—A report on the cotton-growing industry of St. Vincent is given in the *Rep. Agric. Dept., St. Vincent*, 1915–16. At the commencement of the planting season only a small proportion of the 1914–15 crop had been sold, low prices were ruling, and freight and charges were high. As a result of these conditions and the fact that the three previous seasons had been unfavourable, the area devoted to Sea Island cotton was only 2,622 acres, as compared with 4,226 acres in the preceding year, and consisted of 1,531 acres planted by estates and 1,091 acres by small growers. The total yield of cotton amounted to 205,411 lb., valued at £14,366, as against 323,326 lb. in 1914–15. The perennial type of cotton, known as "Marie Galante," was grown exclusively in the Southern Grenadines and a yield of 32,215 lb. was obtained, valued at £872. The weather during the cotton season was again abnormally wet in most districts, and there was an unusually high percentage of stains due to boll diseases. It is estimated that internal boll disease, associated with the attacks of the cotton stainer (*Dysdercus Delauneyi*, Leth.), caused the value of the crop to be reduced by more than £8,000. It has been proved that, besides damaging the cotton and the seed, the cotton stainer enables the fungus causing the internal boll disease to enter the boll and injure or destroy its contents. A study of the cotton stainer, especially in relation to its native food-plants and feeding habits, has therefore been made, and it has been found that the pest is harboured by the silk-cotton tree (*Eriodendron anfractuosum*, DC.) and the John Bull tree (*Thespesia populnea*, Corr.).

As a result of these investigations, the following measures of control are recommended: (1) all the old cotton stalks should be uprooted and burned as soon as possible after picking has been finished; (2) all fruiting silk-cotton and John Bull trees should be destroyed; and (3) the pest should be trapped by means of cotton seed or cotton-seed meal before flowering commences.

The internal boll disease of cotton is characterised by the staining of the lint in unopened bolls and the subsequent rotting of the boll contents. It is caused by infection which takes place in consequence of the puncturing of the wall of the boll by insects, especially *Dysdercus* spp. and *Nezara viridula*. Descriptions of the four principal fungi which act as the infecting organisms have been given recently by W. Nowell, Mycologist of the Imperial Department of Agriculture for the West Indies (*West Indian Bull.*, 1917, **16**, 152).

Reference to cotton cultivation in Barbados is made in the *Rep. Dept. Agric., Barbados*, 1915–16. The area devoted to cotton in the year ended September 30, 1915, was 2,323 acres as compared with 2,985 acres in the previous year. The exports of cotton amounted to 303,681 lb. of estimated value £16,841, as against 285,697 lb., of estimated value £16,820, in 1913–14. In addition, 747,118 lb. of seed were obtained and were converted into oil and cake in the local oil-mill. The yield of cotton per acre was 131 lb. in 1914–15 and 96 lb. in 1913–14. Experiments have been continued with a view to improving the quality and yield of the cotton and have met with considerable success. Two series of experiments are being carried out. In the first series, an attempt is being made to improve the Sea Island and certain indigenous and other varieties by a system of selection of the best formed plants giving large yields of good cotton, whilst, in the second series, efforts are being made in the same manner to improve certain hybrid cottons which have been obtained by crossing some of the best improved varieties among themselves and also by crossing some of the imported cottons with indigenous kinds.

United States.—In *Bulletin* No. 511, 1917, *U.S. Dept. Agric.*, an account is given of the practices actually employed by the average farmer in cultivating cotton in various parts of the Southern States. The collection of this information was undertaken as it was considered that a knowledge of the methods and of the different conditions in which they are applied would be of value to all cotton growers. Nineteen areas were selected for study which were so situated as to represent practically all the conditions occurring in the cotton belt. In general, the results of this enquiry show that the yields of cotton depend largely on climatic conditions, the inherent fertility of the soil, the quantity of manures employed, and the character of the cultivation.

The yields are also directly related to the extent to which the land is tilled after planting. Various types of drainage employed in the cotton belt are described, together with the methods of ploughing, planting, and subsequent cultivation.

In view of the increasing demand for cotton, and especially of Egyptian and other long-stapled varieties, attention is now being directed to the possibility of extending the production in California, and this subject is discussed in *Bulletin* No. 533, 1917, *U.S. Dept. Agric.* Cotton was grown in California about fifty years ago, but the efforts could not be maintained after the re-establishment of normal conditions at the close of the civil war owing to the fact that the varieties grown were similar to, and entering into direct competition with, those grown in the Southern States. The development of the cultivation in California depends on the possibility of producing Egyptian or other long-stapled types. It is probable that California possesses the largest area of new territory readily available for cotton in the whole of the United States. Satisfactory beginnings have been made in the Imperial Valley and the Colorado Valley in the extreme south of the State (cf. this BULLETIN, 1914, **12**, 136), but the San Joaquin and other more northern valleys contain much larger areas of irrigated or readily irrigable land which might be devoted to cotton growing. Experiments have shown that cotton of the Egyptian type can be grown in the southern part of the San Joaquin Valley, whilst in the northern part of this valley and in the Sacramento Valley, Durango and other long-stapled Upland varieties would probably be more successful as they do not require so long a season as Egyptian kinds. Farmers in California are advised to co-operate in efforts to establish a cotton-growing industry, as in this way the handling and marketing of the crop would be facilitated, more effective assistance could be rendered by the Department of Agriculture, and ginning factories and oil-mills could be established under community auspices. Such a policy would also tend to obviate the danger of the introduction of cotton seed from the cotton belt or from Egypt. Such importations are now prohibited by Federal and State enactments in order to preclude the introduction of the boll weevil from the cotton belt and the pink boll-worm from Egypt.

ECONOMIC MINERALS.

Bauxite.—According to the *Ann. Rep. Dept. Mines and Geology, Mysore State*, 1915-16, bauxite has been found in considerable quantities associated with the iron ores of the Bababudans. It is thought probable that these bauxites are lateritic alterations of some of the masses of diorite or hornblende diabase which have intruded the trap flows and iron ores of the Dharwar series. These intrusive masses have been found passing upward into reddish lithomargic

clays in places where they have been preserved from denudation, and these ferruginous clays are closely associated with the bauxites.

A series of analyses of bauxite samples collected from the Kemmangundi area show the following range in composition.

	Per cent.
Alumina (Al_2O_3)	34·20—62·50
Ferric oxide (Fe_2O_3)	5·10—40·70
Silica (SiO_2)	0·26—13·6
Water (H_2O)	20·00—31·90

From a surface inspection it appears probable that a considerable area of this lateritic bauxite may exist on the tops of the hills at the head of the Kemmangundi Valley. The material may prove to be of value in part for the manufacture of refractory bricks and in part for the manufacture of aluminium.

Coal.—In *Bulletin* No. 18, 1917, *New Zealand Geol. Surv.*, J. Henderson gives an account of the Geology and Mineral Resources of the Reefton Subdivision (Westport and North Westland Divisions), and deals with the coal deposits of that area. The coal seams of the Reefton Subdivision occur in three sets of beds of Tertiary age—namely the Mawheranui, Oamaru and Pareora series respectively. The coal of the oldest seams ranges in quality from anthracitic to bituminous, that of the middle seams from bituminous to brown, whilst that of the youngest seams consists of various grades of brown coal. Only the middle set of seams have been worked up to the present, but prospecting operations have been undertaken in connection with the other two sets of seams.

The following analyses are given to show the effect of age on the composition of the coal where the seams lie flat or gently inclined. The analyses represent the average quality of the coals of each series:

	Mawheranui series. *Per cent.*	Oamaru series. *Per cent.*	Pareora series. *Per cent.*
Fixed carbon	66 to 45	50 to 32	40 to 42
Hydrocarbons	33 „ 45	42 „ 50	45 „ 38
Water	1 „ 10	8 „ 18	15 „ 20

The output of the coal-mines of the Reefton Subdivision has been fairly steady for many years, and the production for 1914 was 11,255 tons, the total production of the area up to and including that year being 256,675 tons.

Molybdenite.—According to the *Twenty-fifth Rep. Ontario Bureau of Mines*, 1916, Part I, p. 17, molybdenite deposits are widely distributed in Ontario. The molybdenite occurs as a rule in pegmatite dykes that traverse gneisses and crystalline limestones. In the limestones it is usual to find that the pegmatite is separated from the rock by a band of pyroxenite, and it is in this, as a rule, that the greater part

of the molybdenite is found, associated with pyrite and pyrrhotite. In some cases brown and black mica replace part of the pyroxene. In the more normal pegmatite deposits found in gneiss, tourmaline is frequently associated with the molybdenite, and in some instances the pegmatites pass into quartz veins.

The only production of molybdenite in Ontario prior to 1915 was confined to the years 1901 and 1902, when ore valued at $1,675 was marketed. The war has created a demand for molybdenum as a substitute for tungsten, of which there has been a shortage.

Molybdenite in 1915 was shipped in the form of ore and concentrates, the latter containing 85 per cent. or more of molybdenite (MoS_2). The ore shipments amounted to 192 tons, valued at $12,859. Concentrates amounted to 1,068 lb., worth $1,240. Concentrating was done by the Orillia Molybdenum Company at Orillia and by the Ore Dressing and Metallurgical Division of the Mines Branch at Ottawa. According to a statement by the Deputy Minister of Mines, ferro-molybdenum is to be manufactured in the Province.

Nickel Ore.—The production of nickel in Ontario in 1915 was much greater than in any previous year in the history of nickel mining in that province (*Twenty-fifth Rep. Ontario Bur. Mines*, 1916, Part I, p. 15). The output of nickel-copper matte from the Copper Cliff and Coniston Smelters was 67,703 tons, as compared with 47,150 tons in 1913 and 46,396 in 1914. The nickel content of the matte produced in 1915 was 34,039 tons, making the total production of nickel from the Sudbury region 237,204¼ tons up to the end of 1915. This large increase in the nickel output is due to the demand for nickel-steel for armament and munition purposes generally.

In addition to the nickel from the Sudbury ores, there was produced within the Province, for the first time, metallic nickel obtained by the refining of cobalt-nickel arsenides from Cobalt, Ontario. This metallic nickel, amounting to 11,905 lb., was produced by the Deloro Smelting and Refining Company at Deloro, Ontario.

The total quantity of nickel-copper ore raised during 1915 was 1,339,322 tons, compared with 1,000,364 tons in 1914.

Petroleum.—According to the *Rep. Inspector of Mines, Trinidad and Tobago*, 1916 (*Council Paper* No. 45 of 1917), the number of wells drilled in the Colony during the year was forty-seven, and oil was struck in thirty-four of these. The quantity of oil extracted during the year amounted to 32,475,695 imperial gallons, compared with 23,489,362 gallons obtained during the nine months ended December 31st, 1915.

Mining for manjak was suspended during 1916. There

was no digging of the village lots of asphalt at La Brea during the year, presumably owing to lack of tonnage available for export caused by the war, but it is expected that operations will be resumed when normal conditions are restored.

Much progress has been made by the larger companies in the work of geologically surveying and testing oil lands, and, as the output of many of the producing wells can be increased, it is anticipated that there will be a considerable increase in the Colony's oil production.

The total quantity of oil and oil products exported during the twelve months ended December 31st, 1916, exceeded 34,000,000 imperial gallons, compared with slightly over 14,000,000 gallons during the nine months ended December 31st, 1915.

Tungsten ore.—In a report on the tungsten deposits of Essexvale, Umzingwane District, Southern Rhodesia (*Bulawayo Chronicle*, May 18th, 1917), A. E. V. Zealley, of the Southern Rhodesia Geological Survey, records the occurrence of sixteen reefs of tungsten ore within a rectangular block of country of about nine and a half square miles, lying immediately to the north of Essexvale siding, and mainly west of the railway.

The reefs vary from 200 yards to about a mile in length. Apart from the quartz lenses the width averages about three feet, and is fairly constant. The chief minerals of the reefs are quartz, mica, felspar, fluorite, and topaz. Other minerals present include wolframite, scheelite, pyrite, pyrrhotite, galena, and tourmaline. Pieces of wolframite weighing up to 8 lb. are not uncommon, and masses weighing up to 235 lb. are recorded. Scheelite is found in crystals up to 4 in. long, and is commonly intergrown with the wolframite.

The country rock is hornblende-granite. It is inferred from the absence of any signs of shearing or faulting between the reef and the country rock that the reef material was injected along master joint planes formed by the contraction of the granite on consolidating, and not in fissures caused by faulting. It is considered that this inference may have an important bearing on the persistence of the reefs below the surface.

The wolframite occurs in considerable amount in the surface rubble associated with the reefs, and it is from this loose surface material that the ore has hitherto been obtained. The deposits were first prospected in 1906, and following this there was a small production which ceased in 1909. Interest in the deposits has revived recently, and the returns for 1916 are 2½ tons valued at £467. Altogether about 85 tons of concentrate, valued at £7,165, has been marketed.

Bulletin No. 21, 1916, *Northern Territory, Australia*, is a

report on Hatches Creek Wolfram mines by T. G. Oliver, Director of Mines. These deposits are situated about 800 miles S.S.E. from Darwin, about 700 miles N.N.E. from Oodnadatta, the terminus of the northern railway from Adelaide, and about 350 miles west of the present terminus of the Duchess-Sulliman Creek Railway in Queensland. The approximate position according to the map is lat. 20° 47′, long. 135° 10′.

The ore-bearing area is 4 miles long and 2½ miles wide, and the wolframite occurs in veins from 1 in. to 4 ft. thick, with a matrix of quartz, traversing dioritic rocks. Other associated minerals include muscovite, iron and bismuth oxides, copper carbonates and molybdenite.

The Director of Mines states that the reefs are numerous and well-defined, that they show considerable persistency in size along the line of outcrop, and that with the introduction of capital and better transport facilities the field is destined to become an important producer in the future.

NOTICES OF RECENT LITERATURE

Indian Tea, its Culture and Manufacture. By Claud Bald. 3rd ed. Pp. 373, with 31 illustrations and plan of factory building, Demy 8vo. (Calcutta: Thacker, Spink & Co., 1917.) Price Rs. 7.8; post free, United Kingdom 10s. 5*d.*, abroad 10s. 8*d.*

In view of the importance of the tea industry it is remarkable that there are so few reliable textbooks on this subject. This is probably due to the fact that what amounts to a system of apprenticeship obtains to a large extent in this industry, and the future tea-planter learns his trade not from books but from actual experience on a tea estate. There is much to be said in favour of this practice, but for intending planters a good textbook such as this is of great assistance if only as a record of practice on other estates, and as affording a statement of the principles on which good practice is based.

The present volume has been written by an author who is obviously familiar with all the details concerning the cultivation and manufacture of tea in India, and the clearness with which he has imparted the knowledge he has acquired enables the reader to obtain a good grasp of the subject.

In the preface of this edition the author states that, while his "aim has been to profit by the published results of scientific research, the scope of this work is still limited to the demonstration of such results as have stood the test of practical experience."

The volume comprises twenty-nine chapters, the first thirteen of which are concerned with the formation, cultiva-

tion and manuring of tea estates, and the production of the green leaf; the succeeding ten chapters deal with the manufacture of tea, and give details regarding the various processes concerned with the factory operations in tea manufacture. In the chapters relating to the cultivation of tea much attention is given to the various methods of pruning and manuring, special attention being paid to the subject of green manuring, which is now generally recognised as playing an important rôle on tea estates; explanations are also given of the failures to obtain good results from the practice.

In the concluding six chapters useful details regarding buildings, machinery, means of transport, estate accounts and labour are dealt with. An attempt is also made to estimate the cost of forming and bringing to maturity a tea estate, and of working an estate already in bearing, together with other information regarding the financial side of the industry.

As an appendix are given a specimen form of agreement under the "Workman's Breach of Contract Act" and a schedule used in connection with the employment of cooly labour. There is also a good index. It will be gathered from the foregoing observations that the whole of the operations connected with the tea-planting industry come within the scope of the book, and it may be recommended to anyone desirous of obtaining authoritative information on the subject.

FARM FORESTRY. By J. A. Ferguson, A.M., M.F. Pp. viii + 241, 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 6*s*. net; post free, United Kingdom 6*s*. 5*d*., abroad 6*s*. 7*d*.

This book, which is written primarily for the use of students in Agricultural Colleges in the United States, deals with the formation, upkeep and utilisation of the usually small plantations of trees which are maintained primarily to furnish fuel, posts, lumber, and other wood products for use on the farm. It also deals with the larger tracts of forest lands owned by farmers which are cut from time to time for revenue. Much of the information given has appeared in the *Bulletins* and *Circulars* issued by the United States Forest Service and by other Departments in the States, and the aim of the author has been "to bring together in available form ideas and principles already well known." A brief account is given of the structure, growth and life-history of trees, and then follow chapters on the establishing of a plantation by sowing or planting, the different types of forests and the trees most suitable for planting in various regions of the United States, the natural regeneration of a plantation and its upkeep and protection. The extraction and marketing of the products of the plan-

tation are dealt with, as well as methods for estimating the size of logs and trees, and the content of a plantation in terms of board-measure and of cordwood. A brief account is given of the physical properties of wood, and the methods of preserving woods used for fence posts by means of creosote are described.

TECHNICAL HANDBOOK OF OILS, FATS AND WAXES. By Percival J. Fryer, F.C.S., and Frank E. Weston, B.Sc. Vol. I. Pp. x + 278, with 33 illustrations and 36 plates, Demy 8vo. (Cambridge: University Press, 1917.) Price 9*s.* net; post free, United Kingdom 9*s.* 5*d.*, abroad 9*s.* 7*d.*

This handbook, which is issued in the Cambridge Technical Series, sets out to "explain in as simple a manner as possible the theoretical basis upon which the technical processes rest, as well as to describe the various reactions concerning the industry" [of oils, fats and waxes] and to give a survey of "the whole subject of oils, fats and waxes [*i.e.* including mineral oils and waxes] in a single treatise." In their attempt to carry out this ambitious programme within the modest limits of less than 300 octavo pages, the authors have been driven to such compression that the book is difficult to read. For a textbook that is not readable there is always the alternative that it may be of value as a book of reference, but any book on oils, fats and waxes in English has the misfortune to challenge comparison with Lewkowitsch's *Chemical Technology and Analysis of Oils, Fats and Waxes*, which is one of the best technical textbooks issued, and which is fortunately kept up to date.

After dealing generally with the chemistry and testing of oils, fats and waxes, the authors describe the chief products of this nature and their commercial sources. In this portion of the book there are numerous matters which need attention, some of which may be mentioned.

On p. 119 the source of Chinese tung oil is given as *Aleurites Cordata*, and the oil is discussed merely as a substitute for linseed oil, which hardly does justice to its present industrial position. On p. 129 it is implied that fuzzy cotton seed is always decorticated before expression, which is not the case in this country. The oil palm is twice referred to (pp. 154 and 158) as a species of *Eloesis*, instead of *Elaeis*. Primitive as the native methods of extracting palm oil in West Africa are, they are not quite so crude as the supposed "native" method described on p. 155. On p. 158, in spite of all that has been said and written on the subject of the successful transfer of the palm-kernel crushing industry to this country since the war, the authors say "the kernels are shipped to European ports, chiefly Hamburg (Marseilles during the war)." The only information given about palm-kernel meal is the following:

"At Hamburg extraction with carbon disulphide is carried on. The residue is only fit for manure." If a second edition of this book is called for, the authors would do well to make use of the information on the oil palm and its products given in the West African Oil Seeds Committee's Report. In the account of the whaling industry given on p. 108 no reference is made to the South Atlantic fisheries, which are now the chief centre of the industry, and which have yielded in recent years whale oil and other whale products to the value of nearly £1,500,000 yearly. In Plate VII it appears to be implied that castor seed reaches the mills unshelled, *i.e.* still in the fruit capsule, which is not the case.

It is unfortunate that the authors did not devote to this part of the subject as much care as they have clearly given to the compilation of the chemical and physical data of oils, fats and waxes dealt with.

The book is well produced, and special mention may be made of the numerous plates, chiefly illustrations of machinery supplied by well-known British engineering firms.

A Laboratory Manual of Bituminous Materials. By Prévost Hubbard. Pp. xi + 153, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 7*s.* net; post free, United Kingdom 7*s.* 5*d.*, abroad 7*s.* 6*d.*

This work, written by the Chief of the Division of Road Material Tests and Research of the United States Department of Agriculture, is intended primarily for students of highway engineering, and appears to be well adapted to this purpose.

The first section of the book deals with the classification of the numerous types of bituminous material, their modes of preparation, uses and sampling. It also incorporates a number of technical definitions which have been adopted for these substances by various public authorities. The section concludes with an account of the correct keeping of laboratory records and reports.

The methods of carrying out the numerous tests, which have been devised for the classification of bituminous materials, are described in the second section of 90 pages. Without being unduly lengthy, the directions given are such that a student of average manipulative skill should be able to carry them out successfully.

In Part III are described the characteristics of numerous bituminous substances and the tests which should be made in order to confirm the preliminary identifications. A feature of considerable utility in this section is the inclusion of numerous tables of analytical results, together with the deductions to be drawn, with special reference to the industrial application of the products discussed. The sub-

stances treated in this manner include liquid petroleums and emulsions, solid and semi-solid petroleums and asphalts, tars, pitches, creosoting oils, wood preservatives and bituminous aggregates. This section should be of service to many besides the students for whom it is intended.

The book can be recommended to all who are interested in either the occurrence or use of bituminous materials, since although it contains little concerning the former, the details concerning the latter cannot fail to be of interest.

A HANDBOOK FOR CEMENT WORKS CHEMISTS. By Frank B. Gatehouse, F.C.S. 2nd ed. Pp. viii + 164, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1917.) Price 5*s.* net; post free, United Kingdom and abroad 5*s.* 5*d.*

This book has been written for the assistance of chemists entrusted with the control of the numerous analyses of raw materials, finished products and stores on a cement works. As would be expected in a book of this size, which deals with such a variety of products, the treatment of certain sections of the analytical work is somewhat condensed. It is to be regretted that the author has not lessened this disadvantage by the inclusion of references to more complete discussions of the processes described.

In addition to the account of the examination of the raw materials and finished cement there is also included a description of methods for the examination of water, furnace gases, lubricants, aggregates, cement sand mixtures, and concrete, together with some notes on the mechanical testing of cement.

The Appendix contains a number of tables which should be useful in the laboratory, as well as a few typical analyses of raw materials, cements and waters.

INTRODUCTION TO THE RARER ELEMENTS. By Philip E. Browning, Ph.D. 4th ed. Pp. x + 250, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1917.) Price 7*s.* net; post free, United Kingdom 7*s.* 6*d.*, abroad 7*s.* 9*d.*

The popularity of this book is well shown by the fact that it has now reached its fourth edition, the first having appeared in 1903. Many additions have been made since the first edition was issued, but the general scheme of treatment remains the same. The elements discussed include the rarer alkalis, beryllium, the radio-active elements, the rare earths, gallium, indium, thallium, titanium, germanium, vanadium, niobium, tantalum, molybdenum, tungsten, uranium, selenium, tellurium, platinum metals, gold, and the rare gases of the atmosphere. After a brief account of its history and occurrence, the extraction of each element is described, and a list of typical compounds is given. This is followed by descriptions of processes for its quantitative separation and estimation. A number of experiments are

also suggested as a means of indicating the characteristic behaviour of the element under consideration.

In many cases there is also included a table showing the percentage of the element usually found in its more important minerals. Chapters are devoted to the technical applications of the rarer elements and their compounds and their qualitative separation. A number of useful spectroscopic tables are included. The value of the work is considerably enhanced by numerous references to recent literature on the subject.

THRICE THROUGH THE DARK CONTINENT: A Record of Journeyings across Africa during the Years 1913–16. By J. du Plessis, B.A., B.D., Professor in the Theological Seminary of the Dutch Reformed Church, Stellenbosch, South Africa. Pp. viii + 350, with map and 60 illustrations from photographs, Med. 8vo. (London: Longmans, Green & Co., 1917.) Price 14*s.* net; post free, United Kingdom 14*s.* 6*d.*, abroad 14*s.* 8*d.*

The author gives an interesting account of his travels in Africa, during which he crossed the Continent three times. Starting from Sekondi in the Gold Coast, he traversed the Cameroons, Nigeria, North Congoland, French Sudan, Uganda and British East Africa to Mombasa. Leaving Mombasa he journeyed westwards to Kampala, Lake Edward, Stanleyville, and down the Congo to Leopoldville and Matadi. From Matadi he turned eastwards and travelled along the Kasai River and through Central Congoland to Kongolo, southwards through the Katanga district, and thence through Northern Rhodesia and Nyasaland to Chinde. The journey occupied two years and two months and covered about 17,000 miles, of which approximately 3,000 were traversed on foot. A general description is given of the countries passed through and the peoples inhabiting them, but the main object of the undertaking was the encouragement of Christian missions, and an account is given of the various mission stations visited.

BOOKS RECEIVED

BRITISH GRASSES AND THEIR EMPLOYMENT IN AGRICULTURE. By S. F. Armstrong, F.L.S., Univ. Dipl. Agric. (Cantab.). Pp. vii + 199, Demy 8vo. (Cambridge: at the University Press, 1917.) Price 6*s.* net; post free, United Kingdom and abroad 6*s.* 5*d.*

THE PRESERVATION OF WOOD: A Descriptive Treatise on the Processes and on the Mechanical Appliances used for the Preservation of Wood. By A. J. Wallis-Tayler. Pp. xix + 344, Demy 8vo. (London: William Rider & Son., Ltd., n.d.) Price 10*s.* 6*d.* net; post free, United Kingdom 11*s.*, abroad 11*s.* 3*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

TOBACCOS FROM NYASALAND AND UGANDA

In the following pages an account is given of the results of examination at the Imperial Institute of tobaccos from Nyasaland and Uganda. Tobacco grown in the former country is now well known on the London market, and the samples dealt with below comprise not only tobaccos representative of commercial grades, but also tobaccos produced in the course of experiments conducted by the Department of Agriculture.

Nyasaland

The rapid growth of the tobacco industry in Nyasaland has already been referred to in two articles published recently in this Bulletin (1916, **14**, 1, 615). In the first of these articles an account is given of the results of examination at the Imperial Institute of 12 varieties of tobacco grown experimentally in the Protectorate. The exports of tobacco from Nyasaland rose from 56,826 lb. in 1904–5 to 3,763,014 lb. in 1913–14. During 1914–15 and 1915–16 there was a slight decline in the exports owing to shipping difficulties, but in 1916–17 the record quantity of 4,304,124 lb., local value £112,321, was shipped. Quite recently, however, transport difficulties have become more serious, and it is stated that large quantities of tobacco are being held up through lack of shipping facilities. The total area under tobacco in Nyasaland in 1916–17 was 7,484 acres, as compared with 9,042 acres in 1915–16.

Three sets of samples, grown and prepared on the Government Farm at Namiwawa, Nyasaland, and illustrating (*a*) the results of topping experiments, (*b*) of manuring tests, and (*c*) grades of tobacco forwarded to London for sale, were received at the Imperial Institute in October 1916.

(*a*) *Topping Experiments*

Nine samples were forwarded, stated to represent average samples of flue-cured "Gold Leaf" tobacco, grown and cured under identical conditions, but topped at different heights so as to mature from 7 to 15 leaves per plant.

The samples contained from 8 to 11 leaves each, and their total weight was about 2 lb. The nine samples were very similar, and the following description applies to all of them.

The leaves were about 22 in. long and varied from 7 to 10 in. in width. The colour was light orange-brown, fairly even in some leaves, whilst in others it varied to a medium reddish-brown. Some leaves showed slight greenness. The sample labelled "14 leaves per plant" had the best colour, and the next best was that labelled "15 leaves per plant."

The leaves were of thin, fine texture, but varied in strength. Not more than half of them possessed fair strength, and the remainder were either wholly weak or showed weak papery patches. One or two leaves in each sample were badly spotted. In all the samples most of the leaves were torn and several badly broken.

The nine samples were generally similar in size, colour and texture of leaf, and no variation clearly due to the extent of topping carried out on the plants could be detected. The outstanding feature in all the samples was that the leaves had cured unevenly and showed weak papery patches, chiefly along the midrib; this portion in some cases being of a paler colour, or slightly green. In some instances this part of the leaf had entirely crumbled away, in spite of the fact that the samples as received contained sufficient moisture to maintain ordinary tobacco in good condition. This defect rather obscured

any effects which the extent of the topping may have had on the tobacco, but so far as can be judged from these samples it seems reasonable to suppose that, on the whole, higher topping, viz. to produce 14 to 15 leaves, is not disadvantageous.

(b) *Manurial Experiments*

Six average samples of "Conqueror" flue-cured tobacco, of a total weight of 2 lb., were received. They were stated to be taken from plots manured as follows:

1. Lime.
2. Cattle manure.
3. Cotton seed.
4. "Control."
5. Lime and cattle manure.
6. Lime and cotton seed.

The samples were as follows:

(1) "*Lime.*"—These leaves were mostly about 20 by 10 in., a few being larger. The colour was uneven, varying from light orange-brown to light reddish-brown. Many leaves were badly spotted or discoloured, and some showed slight greenness. The texture was thin and fine, and some of the leaves showed fair strength. Many leaves were torn.

(2) "*Cattle Manure.*"—These leaves were from 22 to 23 in. long and from 10 to 14 in. wide. The colour and texture were similar to those of sample 1 ("Lime"), but only a few spots were noticed. The sample was in a fair condition, but some of the leaves were rather torn.

(3) "*Cotton Seed.*"—These leaves were from 20 to 22 in. long and 10 to 13 in. wide. The colour and texture were similar to those of sample 1 ("Lime"), and the leaves were in fair condition though some of them were rather torn.

(4) "*Control.*"—The leaves were from 21 to 23 in. long and from 11 to 14 in. wide. The colour and texture were similar to those of sample 1 ("Lime"), but the leaves were a good deal torn.

(5) "*Lime and Cattle Manure.*"—These leaves were from 22 to 24 in. long and from 10 to 14 in. wide. The colour was generally the same as that of sample 1 ("Lime"), but the greenness was a little more pronounced in some cases. The sample was of fine texture, and the best

leaves had slightly more body and strength than those of sample 1 (" Lime "), but those showing greenness were weak and brittle. Some of the leaves were badly broken.

(6) *" Lime and Cotton Seed."*—These leaves were from 22 to 23 in. long and from 12 to 15 in. wide. The colour was generally the same as that of sample 1 (" Lime "), but the greenness was rather more pronounced in some leaves. The texture was similar to that of sample 5 (" Lime and Cattle Manure "). Most of the leaves were in fair condition, but some were badly torn.

These samples were submitted to chemical examination with the following results, in comparison with a sample of " Conqueror " tobacco from Nyasaland, previously examined at the Imperial Institute (*loc. cit.*, p. 4). The figures are calculated to correspond to 14 per cent. of moisture, which is the quantity regarded as necessary to maintain the leaves in good order during transport.

	(1) Lime.	(2) Cattle manure.	(3) Cotton seed.	(4) Control.	(5) Lime and cattle manure.	(6) Lime and cotton seed.	Previous sample of "Conqueror" tobacco from Nyasaland.
Moisture . . .	14·0	14·0	14·0	14·0	14·0	14·0	[illegible]
Nicotine . . .	2·6	2·8	2·4	3·1	4·0	4·0	2·2
Nitrogen . . .	2·9	3·1	2·4	2·2	3·5	3·5	1·8
Ash . . .	14·4	14·1	13·9	13·3	14·7	13·5	10·5

The ash contained:

Lime	CaO	23·3	22·2	21·4	24·3	24·7	25·9	22·9
Magnesia	MgO	7·3	7·7	6·6	7·6	7·9	7·5	5·5
Potash	K_2O	32·8	31·6	32·6	30·5	31·2	29·3	29·4
Soda	Na_2O	0·4	1·1	1·5	1·4	0·6	0·4	6·0
Sulphates, expressed as sulphuric anhydride	SO_3	1·9	2·6	2·4	2·8	2·9	2·1	1·6
Chlorides, expressed as chlorine	Cl	1·3	1·9	0·8	1·2	3·0	1·6	0·8

All six samples had a moderately strong and fairly pleasant flavour when smoked, with good burning properties, and yielded a white to grey ash. The " control " sample had in addition a faintly sweet flavour not possessed by the others. In the case of samples 5 (" Lime and Cattle Manure ") and 6 (" Lime and Cotton Seed ")

the flavour was slightly pungent and a little stronger than in the other cases. It is difficult to judge of the flavour of tobacco in samples such as these, which have not been matured, but there is no reason to suppose that any of these six samples would not improve on storage, and be of good flavour when properly matured.

The samples on the whole may be regarded as representing pipe tobaccos of good flavour and burning qualities, though they are not of such good quality as the previous sample of "Conqueror" tobacco from Nyasaland referred to above, which had a pleasant, mild, sweetish taste, and was reported on very favourably by London buyers.

The effect of the different methods of manuring on the quality of "Conqueror" leaf has not been very marked. In certain of the samples a slightly stronger flavour has been produced, more particularly in the case of the leaves grown on ground treated with lime and an organic manure. The chemical investigation shows that an increase of the amount of nitrogen in the leaves has taken place in certain cases owing to the manuring, and is most marked in samples 2 ("Cattle Manure"), 5 ("Lime and Cattle Manure"), and 6 ("Lime and Cotton Seed"). It is accompanied in the case of the last two samples by an increase in the percentage of nicotine. This rise in the amounts of nitrogen and nicotine accounts for the slightly greater pungency in flavour of these tobaccos. The burning properties have not been noticeably altered by the manuring in any case.

The leaves throughout had cured rather unevenly as in the case of the samples illustrating topping experiments (see p. 466), and this factor may to some extent have masked the effects of varying the manurial treatment. There were, however, indications of improvement in size and substance of the leaf due to the use of lime and a nitrogenous manure together, whereas the poorest sample in size and quality of leaf was the one from the crop treated with lime alone.

It may be added that this set of samples as received at the Imperial Institute was in rather too damp a condition for the United Kingdom market, and that the discoloration of the leaves appeared to be partly due to

this excess of moisture facilitating "heating" during transit.

These experiments with different manures are well worth continuing. Though it is not safe to draw final conclusions from the results of examination of this single series of samples, it may be pointed out that the results now reported indicate that cotton seed is a safe manure for maintaining the special characteristics of Nyasaland tobacco, viz. low nitrogen and high potash, and that by the judicious use of lime and organic manures it may prove possible to increase the yield of tobacco in Nyasaland without interfering with its special characteristics. These suggestions are, however, entirely provisional, and they will need confirmation by the results of further trials before they can be put forward as definite conclusions.

(c) *Commercial Grades*

In order to strengthen the position of Nyasaland tobacco on the home market, a system of grading has been adopted by most of the farmers. For this purpose the tobacco is classified into two groups; viz. (*a*) mahogany and dark leaves of heavy or good body, suitable for pipe and plug tobacco, and (*b*) brighter and thinner leaves suitable for cigarette tobacco. The different grades in each group are designated *A.D.*, *A.E.*, *A.F.*, etc., and *B.B.*, *B.C.*, *B.D.*, etc., respectively. A description of the grades *A.E.* to *A.H.* and *B.B.* to *B.H.* supplied by the Director of Agriculture, Nyasaland, has been given in this BULLETIN (1916, **14**, 615).

Six samples, described as common grades of "Gold Leaf" tobacco, and weighing in all 2¾ lb., were received for examination. They were as follows:

"*Grade A.D.*"—These leaves mostly measured 22 by 11 in., but a few were larger, measuring up to 24 by 14 in. They were mostly of a variable light orange-brown colour, but some were of a greenish-yellow tint, and many showed slight greenness. The leaves were thin and fine in texture. About half of them possessed fair strength, whilst others were either wholly weak or weak in places, this being particularly marked in the greenish leaves. Several of the leaves were spotted and most of them were torn.

"*Grade A.E.*"—These leaves were from 19 to 21 in. long and from 7 to 11 in. wide. The colour varied from yellow to light orange-brown. Most of the leaves were rather badly spotted, and the sample showed slight greenness throughout. The texture and conditions were similar to those of grade *A.D.*

"*Grade A.F.*"—These were from 22 to 23 in. long and from 7½ to 11 in. wide. The colour varied from light orange-brown to medium reddish-brown, many leaves being mottled. Slight greenness was noticed in one or two cases. The leaves were fairly fine and of thin texture, and had slightly more body and strength than grades *A.D.* and *A.E.*, but a few were weak in places. The sample was in fair condition on the whole, but many leaves were slightly spotted.

"*Grade A.G.*"—The leaves varied from 22 to 24 in. in length and from 7 to 11 in. in width. The colour varied considerably, most of the leaves being medium to dark reddish-brown. Some showed greenness along the midrib, and others were splashed with bright yellow. A few were slightly mottled with dull reddish-brown and greenish-brown tints. The latter leaves were fairly fine in texture, of fair body, and strong. The rest of the leaves were thin to moderately thick, and varied in strength, many of them being weak. Several badly spotted and torn leaves were present.

"*Grade A.H.*"—These leaves were about 16 by 6½ in. in size, a few leaves being larger. The colour was mostly a medium dull brown to reddish-brown, but in a few cases orange-brown. The leaves were fairly fine and thin in texture. Some were of fair strength, and others weak, while several showed greenness or spots.

"*Grade B.G.*"—These leaves were from 16 to 18 in. long and from 5½ to 10 in. wide, and in colour showed various tints of brown with greenish patches. This sample was badly broken, some leaves being in shreds.

All six grades had good burning properties and left only a small amount of grey ash. None of them had the pleasant sweet taste generally met with in mature Nyasaland tobacco. Grade *B.G.* had the mildest flavour. Grades *A.D.*, *A.E.*, and *A.F.* represented mild pipe

tobaccos of fairly good flavour, and grades *A.G.* and *A.H.* represented fairly strong flavoured pipe tobaccos.

All these tobaccos would no doubt improve in flavour on keeping.

These six tobaccos were all inferior to the best qualities of Nyasaland tobacco, which come on this market, but they should all be saleable, especially as the bulk sent for sale to London probably arrived in better condition than these small samples. The six samples as received at the Imperial Institute might be arranged in the following descending order as regards quality: *A.E.*, *A.G.*, *A.F.*, *B.G.*, *A.D.*, *A.H.*

Uganda

Tobacco is grown on a comparatively small scale in Uganda, mainly by the natives for local consumption, and the exports are quite insignificant, not exceeding 3 cwts. annually during the past five years. The crop is stated to do well in the drier parts of the Protectorate, but very little interest is taken in tobacco growing on plantations generally, although a few planters grow and sun-cure a small quantity for local consumption.

Three samples of tobacco grown and cured on the Nambeya Estate, Bulemezi, Mengo District, about 30 miles north of Kampala, were received for examination at the Imperial Institute towards the end of 1916. They were as follows:

No. 1.—"From Virginia seed locally grown. Sun-cured and slightly fermented." This consisted of ten leaves, which were of fairly uniform size, measuring about 18 in. in length and 9½ in. in width. They were of a medium reddish-brown colour, of thin, fine texture and on the whole fairly strong; some leaves, however, were inclined to be papery and weak. Several of the leaves were rather broken, but the others were in good condition.

No. 2.—"From Virginia seed locally grown, the same as sample 1; sun-cured and slightly fermented." It was stated that this tobacco was never taken out of the nursery, but was cultivated there. The sample consisted of eighteen small leaves mostly measuring from 14 to

16 in. in length and from 6 to 7 in. in width (a few measuring 17 by 8 in.), and varying in colour from light to medium reddish-brown. The leaves were thin, of fine texture, and on the whole fairly strong, but some were weak in places. There were also present a few fairly thick leaves, varying from medium to dark reddish-brown in colour.

The sample on the whole was of poor appearance, most of the leaves being spotted or discoloured and several torn.

No. 3.—"Turkish tobacco from imported seed, air-cured under verandah, bulked, and fermented slightly." Nineteen small leaves, measuring from about 9 to 11 in. in length and from 4 to 5 in. in width, and of a medium reddish-brown colour, with an occasional greenish or orange tint. The leaves were thin and of fine texture, but on the whole were lacking in strength. Several leaves were rather torn, and a few slightly spotted, but otherwise the sample was in good condition.

Owing to the small size of the samples only a preliminary examination could be made.

Representative portions of samples 1 and 2 were mixed together and submitted to chemical examination, with the following results, which are calculated for leaves containing 14 per cent. of moisture :

	Per cent.
Moisture	14·0
Nicotine	1·9
Nitrogen	2·7
Ash	18·7

The ash contained :

Lime	CaO	26·0
Magnesia	MgO	9·4
Potash	K_2O	34·6
Soda	Na_2O	3·1
Sulphates, expressed as sulphuric anhydride	SO_3	3·0
Chlorides, expressed as chlorine	Cl	1·9

The above results indicate that the leaf is of satisfactory composition, containing a low percentage of nitrogen and nicotine and a large proportion of potash.

Sample No. 3 was too small for chemical examination and none of the samples was large enough for commercial valuation.

The samples were subjected to burning and smoking tests with the following results:

No. 1.—In cigarette form this tobacco burnt easily and held fire well, yielding a grey ash. The smoke was pungent.

No. 2.—This tobacco burnt easily and held fire well, leaving a grey ash. The smoke had a moderately pungent flavour, quite similar to that of sample 1, but somewhat milder.

No. 3.—This tobacco burnt well and held fire well, yielding a whitish-grey ash. It had a pleasant, sweetish, mild flavour, but entirely lacked the aroma characteristic of the smoke from "Turkish" tobacco.

As pointed out already, these samples were too small to permit of detailed examination and commercial valuation. The results now obtained show, however, that the soil in which these tobaccos were grown is quite suitable for this crop, as it produces leaves containing a large proportion of potash, which therefore burn well, and which are not excessively rich in nitrogen and nicotine and will therefore not be too pungent when they have been properly cured and fermented. For the proper preparation of Virginia tobacco "barn-curing" as described in this BULLETIN (1910, **8**, 177) is essential. Similarly for the preparation of Turkish tobacco the process described in this BULLETIN (1913, **11**, 326) should be followed in order to obtain a product having the characteristic aroma and flavour associated with this type of tobacco.

THE OIL-SEED INDUSTRY OF RHODESIA

THE cultivation of oil seeds promises to become an important industry in Rhodesia. At present ground nuts and sunflower seed are the only oil seeds produced commercially, but experiments conducted at the Agricultural Experiment Station, Salisbury, Southern Rhodesia, have indicated that other oil seeds, including linseed, sesame seed, niger seed and *Madia sativa* seed (known locally as "Chile oil seed") may be grown successfully.

According to the *Report of the Director of Agriculture,*

Southern Rhodesia, 1916, the cultivation of ground nuts is steadily increasing owing to the introduction by the Department of improved varieties. The total production in 1916 amounted to 800 tons, and 3,043 acres were under the crop in that year, the average yield per acre being 5·2 cwts. In the preceding year 325 tons were produced from 1,523 acres, an average of 4·9 cwts. per acre. Most of the crop is utilised in the Salisbury Oil Mill for the production of oil and soap, the quantity of unshelled nuts which the factory offered to purchase amounting to 500 tons in the case of the 1916–17 and 1917–18 crops. Owing to the disturbed conditions, an experimental shipment of ground nuts to Europe in 1916 did not give encouraging results, but a market for the surplus produce has been found in the Union of South Africa, where the nuts are largely used for food by the natives employed on the mines.

The total area under sunflower seed in Southern Rhodesia in 1916 amounted to 1,766 acres, and 500 tons of seed were harvested, the average yield in the districts best suited to the crop being 800 lb. per acre. In that year 8,774 cwts. of seed valued at £4,140 were exported from Southern Rhodesia to the United Kingdom, as compared with 1,358 cwts. valued at £783 in 1915, in which year sunflower seed first appears in the export returns. The Director of Agriculture in his *Report* for 1916 states that there is every reason to anticipate that this product will become one of the staple exports of the country. In order to ensure the success of the industry, however, it is considered that it may be necessary to find a use for the stems, and with this end in view an investigation was conducted recently at the Imperial Institute, the results of which were published in the last number of this BULLETIN (1917, **15**, 329).

Oil seeds are grown to a small extent by farmers in Northern Rhodesia, and the produce is stated to find a ready sale locally, but so far they have not appeared in the export returns. Ground nuts and castor seed are widely grown in some parts of the country by the natives, and the oils extracted for local use.

Various oil seeds are also being grown at the Govern-

ment Experimental Gardens at Mazabuka and Chilanga, Northern Rhodesia, and samples of castor seed, sunflower seed, sesame seed and linseed produced there were received recently at the Imperial Institute. The results of their examination are given below.

Castor Seed

No. 1.—"*Ricinus sanguineus Zanzibaris*, Red Zanzibar Castor bean." These were clean reddish-brown castor seeds, of moderate and uniform size. The average weight of a single seed was 0·5 gram. The seeds contained 5·2 per cent. of moisture, and yielded 48·4 per cent. of oil, equivalent to a yield of 51·1 per cent. from the dry seeds. The oil had the usual consistency and appearance of castor oil, and its acid value was 1·2.

These castor seeds contained a normal amount of oil and were in good condition. The maximum controlled price of castor seed in the United Kingdom was £37 per ton at the beginning of December 1917, but in normal times the value is about £11 per ton.

Sunflower Seed

No. 2.—"*Helianthus annuus*. Sunflower, black." Fairly large black "seeds" of uniform size, clean and practically free from immature seeds. The "seeds" consisted of kernel 56 per cent. and husk 44 per cent. The whole "seed" contained 7·4 per cent. of moisture, and yielded 25·5 per cent. of pale yellow, liquid oil, having an acid value of 4·3. This yield was equivalent to 27·5 per cent. from the dry whole "seed," or 49·1 per cent. from the dry kernels.

These "seeds" contained a satisfactory percentage of oil and were in good condition. This black variety of sunflower "seed" is evidently superior to the "striped Russian" "seed" (see p. 477).

Sunflower "seed" is not quoted in the market reports at the present time, but the Imperial Institute was recently informed by brokers that Rhodesian sunflower "seed" equal in quality to previous consignments from that country would be worth about £20 per ton in London (May 1917).

No. 3.—"*Helianthus annuus.* Striped Russian Sunflower." This sample consisted of large bold "seeds," of cream colour with dark-brown longitudinal stripes. Only about a quarter of the "seeds" contained kernels, the majority of them being immature. The mature "seeds" selected for analysis consisted of kernels 45 per cent. and husks 55 per cent. The mature, whole "seeds" as received contained 5·1 per cent. of moisture, and yielded 20·7 per cent. of pale yellow liquid oil, with an acid value of 2·4. This yield of oil is equivalent to 21·5 per cent. from the dry whole "seed," or 48·8 per cent. from the dry kernels.

Sunflower "seed" represented by this sample would be of no value as a source of oil, owing to the presence of a large proportion of immature "seeds" devoid of kernels. The mature "seeds," moreover, gave a low yield of oil, owing to the large proportion of husk, and this variety cannot therefore be recommended for cultivation in Rhodesia, unless further trials show that it will give a better quality of "seed" than that represented by this sample.

Sesame Seed

No. 4.—"*Sesamum indicum.* Sesame." These were very small, pale brown seeds, in clean condition. They contained 4·9 per cent. of moisture, and yielded 50·4 per cent. of light brownish-yellow liquid oil equivalent to a yield of 53·1 per cent. from the dry seeds. The oil had an acid value of 4·5.

These sesame seeds contained a normal quantity of oil and were in good condition. The maximum controlled price of sesame seed in the United Kingdom in December 1917 was £32 per ton, and there should be no difficulty in disposing of consignments equal in quality to the present sample in this country.

In this connection it should be noted that before the war sesame seed was chiefly crushed on the Continent owing to the fact that in several Continental countries the inclusion of a certain quantity of sesame oil in margarine was compulsory to facilitate its detection when used to adulterate butter. This factor raised the price of sesame

seed, with the result that British margarine makers used other cheaper and equally good oils. The seed is, however, now being crushed in this country, and this use will be continued and extended if the price of the seed remains at about the same level as that of other oil seeds.

LINSEED

No. 5.—"*Linum usitatissimum.* White flowering linseed." This sample consisted of fairly clean, small linseed, a fair proportion of immature and unripe seed being present. The seed as received contained 6·3 per cent. of moisture and yielded 32·5 per cent. of yellowish-brown liquid oil, equivalent to a yield of 34·7 per cent. from the dry seeds. The oil had an acid value of 2·6.

No. 6.—"*Linseed, Pskoff.*" This seed was rather smaller and of lighter colour than the "white flowering" linseed, No. 5. The sample contained a fair proportion of earth and dirt but a smaller quantity of immature and unripe seed than sample No. 5. The seed when freed from earth by sifting contained 6·3 per cent. of moisture and yielded 33·7 per cent. of yellowish-brown liquid oil, equivalent to a yield of 35·9 per cent. from the dry seed. The oil had an acid value of 2·1.

The samples of "White flowering" and "Pskoff" linseed (Nos. 5 and 6) consisted of small seeds of rather poor appearance. The yield of oil was, however, in each case within the usual limits (31 to 36 per cent.) for commercial linseed.

The maximum controlled price of linseed in the United Kingdom in December 1917 was £29 15*s.* per ton for Calcutta seed (pure basis), and £28 per ton for Argentine seed (4 per cent. basis). In June 1914 Calcutta seed was selling at about 50*s.* per quarter of 410 lb. (£13 13*s.* per ton) in London, and La Plata linseed at about 54*s.* per quarter of 416 lb. (£14 10*s.* per ton) in Hull.

The United Kingdom is the largest consumer of linseed among oil-seed crushing countries and could without difficulty use all the linseed produced within the Empire. As linseed oil can now be refined for edible purposes, the demand for it in this country is likely to increase.

A NEW PALM NUT FROM COLOMBIA

EARLY in the present year a supply of palm nuts was received at the Imperial Institute from the Director of the Tropical Agricultural Station, San Lorenzo, Colombia.

The palm is very abundant in the Magdalena valley, and bears large racemes of fruits (nuts). The nuts furnish an oil much valued in the tropical parts of Colombia and used locally mainly for soap-making. The oil is also employed for cooking and as a lubricant and an illuminant, whilst it is also reputed to possess medicinal properties in the treatment of skin diseases.

Two varieties of the palm are stated to occur; one bearing large fruits and found in the lower Magdalena valley, where it is known as "Corozo," and one with smaller fruits occurring in the higher Magdalena and known as "Cuesco." Specimens of the larger variety only were forwarded to the Imperial Institute. These have been compared with palm fruits in the collections of the Natural History Museum and appear to correspond most closely to those of *Scheelea excelsa*, Karst. (= *Attalea excelsa*, Mart.). This species is stated by Karsten in his *Flora of Colombia* (1862–9) to occur in the Magdalena valley, together with a second species, *S. regia*. The latter has much smaller fruits than *S. excelsa*, and may possibly be the "Cuesco" palm referred to above, but in the absence of complete herbarium specimens it is not possible to identify the palms with certainty.

The nuts received at the Imperial Institute were bluntly pointed at the ends and measured from 2 to 2½ in. in length and from 1 to 1¼ in. in diameter. Each consisted of a very dense, hard woody shell, enclosing two or three kernels; 60 per cent. of the nuts contained three kernels and 40 per cent. only two kernels.

The kernels were similar in appearance to those of "Babassu" nuts (*Attalea funifera*) received at the Imperial Institute from South America, but were smaller (see this BULLETIN, 1917, **15**, 38). They were rounded at the ends, and measured from 1¼ to 1½ in. in length, with an elliptical cross section measuring ¼ by ⅜ in. at the middle of the kernel. Externally the kernels were of

dark reddish-brown colour streaked with pale brown; internally they were white and of firm consistency.

The removal of the kernels from the nuts was difficult, owing to the hardness of the shells and to the fact that even when the shells are broken the kernels still fit firmly in the pieces of shell.

On examination the kernels were found to contain 4 per cent. of moisture and to yield 65·4 per cent. of fat, equivalent to a yield of 67·6 per cent. from the dry kernels. The fat was of pale cream colour and of similar appearance to coconut oil but with a less noticeable odour.

The fat was submitted to chemical examination with the following results:

	Present sample.	Figures recorded for: Palm kernel oil.	Coconut oil.
Specific gravity at $\frac{100° C.}{15° C.}$	0·864	0·873	0·874
Melting-point of fat (open tube method)	29° C.	26°–29° C.	23°–26° C.
Solidifying point of fatty acids	25·3° C.	20·0°–25·5° C.	21·2°–25·2° C.
Acid value[1]	0·6	—	—
Saponification value[1]	224·6	245–248	260–262
Iodine value . . *per cent.*	35·2	14·0–17·5	7·9
Hehner value	93·0	—	—
Insoluble fatty acids . *per cent.*	92·3	—	—
Unsaponifiable matter . „	0·7	—	—
Volatile acids, soluble[2]	2·1	5·0–7·6	6·6–8·0
Volatile acids, insoluble[2]	3·0	10–12	15–20

[1] *Milligrams of potash for 1 gram of fat.*
[2] *Cubic centimetres of decinormal alkali required to neutralise acid from 5 grams of fat.*

The difficulty of shelling these nuts and separating the kernels may prevent their exploitation on a commercial scale; but if the kernels can be placed on the market in quantity, they should realise about the same price in the United Kingdom as palm kernels, the official ("controlled") price of which is at present £26 per ton in Liverpool (December 1917), and which before the war realised about £17 to £23 and occasionally as much as £25 per ton.

The fat of these kernels is similar in appearance to the fats derived from the kernels of several kinds of palm, but it differs somewhat markedly from these in chemical character, as is seen from the low saponification

value, high iodine value and the comparatively small amounts of volatile acids present. It would not pay to ship the entire nuts to Europe, but if the kernels can be offered in commercial quantities there is no doubt that they would be readily saleable as a source of edible fat.

THE UTILISATION OF LINSEED STALKS

THE utilisation of the stalks obtained in the cultivation of the flax plant for seed is a problem to which a good deal of attention has been, and is being, given in Argentina, United States, Canada and elsewhere, where linseed is grown on a large scale. The usual plan is to burn the stalks as fuel, and so long as only small quantities are available this is the best course to adopt, the ashes being returned to the soil as manure.

Where, as in the three countries mentioned, thousands of tons of stalks are produced each year, it is worth while to consider other possibilities, of which there are at present two, viz. (1) the production of tow or short flax fibre from the stalks, and (2) the manufacture of pulp or paper. Both these methods are being tried to some extent in Canada and the United States (cf. this BULLETIN, 1916, **14**, 301). The adoption of either of these processes, however, involves considerable outlay for plant and is only possible where very large supplies of the stalks are available and where there is a large local market for the products, as the latter are too low in value to be suitable for export except under special circumstances.

Although at the present time linseed is grown on a very limited scale in Rhodesia, mainly as a special feeding stuff for animals, the interest in oil-seed crops is growing rapidly in that country (see p. 475), and in the event of linseed becoming a staple crop it would be to the advantage of the farmers if a remunerative outlet could be found for the stalks. In order to ascertain the possibility of utilising Rhodesian linseed stalks for the production of tow and the manufacture of pulp or paper, a sample was forwarded to the Imperial Institute by the British South Africa Company in September 1916.

The sample weighed 21 lb. and consisted of hard, brittle, greenish-yellow stalks, measuring from 15 in. to 2 ft. in length and from $\frac{1}{16}$ to $\frac{1}{12}$ in. in diameter. Each stalk branched at the top into slender branchlets, and had a brown woody root measuring from 1 to 2 in. in length and about $\frac{1}{8}$ in. in diameter.

The stems were evidently those of linseed grown for seed, and were too branched and too short for the preparation of flax fibre.

The material as received was found to contain 11·1 per cent. of moisture. The dried material contained 50 per cent. of cellulose and yielded 3·6 per cent. of ash. The ultimate fibres extracted from the stems measured from 12 to 25 mm. in length.

Paper-making Trials

The entire stalks were examined as a paper-making material by the soda process with the following results :

Caustic soda used.		Conditions of boiling.		Parts of soda consumed by 100 parts of stalks.	Yield of dry unbleached pulp, expressed on the material as received.
Parts per 100 parts of stalks.	Parts in 100 parts of solution.	Time in hours.	Temperature.		*Per cent.*
18	4	5	150° C.	14·5	44

The yield of pulp obtainable from flax straw is similar to that obtained from esparto grass of fair quality. The pulp yields a fairly strong paper of medium brown colour, but it does not bleach easily, and even with much larger quantities of bleaching powder than could be used on a commercial scale the colour is not greatly improved. The length of ultimate fibre in the paper was 2·0 to 4·0 mm.

It may be mentioned that experiments made by the United States Bureau of Plant Industry showed that flax straw pulp prepared by lime-boiling also could not be bleached.

With a view to ascertaining whether the sulphite process would give better results than the soda process,

the following experiments were made at the Imperial Institute :

Strength of sulphite liquor.		Conditions of boiling.		Yield of dry unbleached pulp, expressed on the material as received.
100 parts contained the equivalent of		Time in hours.	Pressure and temperature.	*Per cent.*
Lime (CaO).	Magnesia (MgO).			
(1) 0·7	0·3	8	5 atmospheres at 150° C.	46
(2) 0·7	0·3	3	3 atmospheres at 145° C.	45

Boiling by the sulphite process thus gave about the same yield of pulp as the soda process, but the pulp was of much better colour, and could be readily bleached to a fairly satisfactory tint.

Preparation of Tow from the Straw

Tow prepared in the United States from flax straw has been used as a stuffing material in upholstery, and its use for paper-making has also been suggested. Experiments made at the Imperial Institute showed that by crushing the stalks between rollers, and beating and thrashing, about 23 per cent. of coarse tow was obtainable from the material. The last traces of "shieve" were difficult to remove. The tow was examined as a paper-making material with the following results :

Caustic soda used.		Conditions of boiling.		Parts of caustic soda consumed by 100 parts of tow.	Yield of dry unbleached pulp.
Parts per 100 parts of tow.	Parts in 100 parts of solution.	Time in hours.	Temperature.		*Per cent.*
16	4	6	150° C.	13·0	50

The paper obtained in this way is somewhat tougher than that from the whole stems, but it does not bleach easily, and the improvement in quality is too slight to make it worth while to separate the tow from shieve for paper-making purposes.

The shieve was examined as a paper-making material with the following results:

Caustic soda used.		Conditions of boiling.		Parts of caustic soda consumed by 100 parts of shieve.	Yield of dry unbleached pulp.
Parts per 100 parts of shieve.	Parts in 100 parts of solution.	Time in hours.	Temperature.		*Per cent.*
18	4	8	150° C.	14·5	43

The paper thus obtained is, as might be expected, inferior in strength and colour both to that obtained from the tow and to that yielded by the entire stems, and it cannot be bleached. Such pulp could only be used for very low grade paper, and might prove unworkable unless mixed with a longer-fibred material.

Commercial Valuation

(1) Samples of the linseed stalks and of the tow and paper prepared from them at the Imperial Institute were submitted to a firm of paper manufacturers for an opinion as to their commercial value. The firm considered that it would be impracticable to separate the tow on a commercial scale, and that it would be better to make soda pulp from the entire stalks and use it in the unbleached state to make brown paper. The firm added that from the quantity of shieve present in the unbleached pulp it would appear probable that the price of "half-stuff" prepared from linseed stalks would in normal times be considerably less than that of "half-stuff" obtained from wood, which is only about £8 to £9 per ton (unbleached).

(2) Tow made from flax straw in the United States is stated to be sold at \$16 to \$32 per ton, according to quality, for upholstery purposes, and a sample of the tow prepared at the Imperial Institute was therefore submitted to a firm of merchants dealing in upholstery materials in London. This firm stated, however, that the material was too short and weak for use in upholstery

in this country, and would probably only be suitable for paper-making. The objections to its use for this purpose are stated above (p. 483).

THE PRODUCTION OF SISAL HEMP

During the past year specimens of Sisal hemp from the Union of South Africa, British Honduras and the Belgian Congo have been received at the Imperial Institute, and an account of their examination is given in the following pages.

South Africa

The samples of Sisal hemp which are the subject of this report were forwarded to the Imperial Institute by the Principal of the School of Agriculture at Cedara, Natal, in January 1917. They were as follows:

No. 1.—" Fibre from large thorny leaves." This consisted of cream-coloured fibre of fair lustre, fairly well cleaned and prepared, but with some adherent pithy matter, especially at the tips. The fibre was finer, softer and more pliable than is usual for Sisal hemp of the best grades, and was of very fair though rather uneven strength. The fibres measured from 3 to 5 ft., the average being about 4 ft.

No. 2.—" Fibre from Sisal leaves No. 2." This fibre was nearly white, very lustrous, and coarse. A little pith was present at the butt-ends and a small amount of epidermis at the tips, but the fibre was otherwise well prepared, and the strength was very good. The fibres were even in length, varying only from 4 ft. to 4 ft. 6 in.

A specimen of the leaf from which each fibre had been prepared was also received. Leaf No. 1, which bore spines on the edges, measured 48 in. from base to tip, 5 in. in width and about 1¾ in. in thickness at the base. Leaf No. 2 bore no spines; it was 55 in. long and 3 in. wide.

The two samples of fibre were submitted to chemical examination with the following results, compared with

figures recorded for Sisal hemp from the East Africa Protectorate :

	Present samples. No. 1.	Present samples. No. 2.	Sisal hemp from the East Africa Protectorate.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	8·7	8·2	9·6
Calculated on the dry fibre :			
Ash	1·3	1·6	0·8
α-Hydrolysis, loss . . .	12·1	9·3	11·3
β-Hydrolysis, loss . . .	13·7	10·8	14·8
Acid purification, loss . .	0·5	1·3	2·[illegible]
Loss on washing in water .	nil	1·3	—
Cellulose	79·0	79·2	77·4

Samples of the fibres were submitted to merchants in London, who reported that No. 1 was equal to a "medium" grade of British East Africa Sisal hemp and worth £92 to £97 per ton, in London; whilst No. 2 compared favourably with "prime" British East Africa Sisal hemp and was worth £95 to £100 per ton (June 1917). Before the war the values would have been £25 to £26 and £27 to £28 respectively.

The results of the examination of these samples of Sisal hemp from Natal showed that they compared favourably in composition and chemical behaviour with East African Sisal hemp of good quality, sample No. 2 being particularly good. Sample No. 1 was a soft fibre of different character from No. 2, which was a stiff fibre of very good quality. The appearance and value of both fibres could have been improved by a little more care in the cleaning of the tips and butts and by brushing to remove pith.

British Honduras

A specimen of Sisal hemp grown and prepared at the Botanic Station, British Honduras, was received in March 1917. It consisted of coarse, lustrous fibre varying in colour from cream to pale buff. A small quantity of pith was present, which could be removed by brushing.

The fibre, which was of very good strength and varied in length from 4 to 5 ft., was examined chemically with the following results compared with those obtained in the case of Sisal hemp from the East Africa Protectorate :

	Present sample.	Sisal hemp from the East Africa Protectorate.
	Per cent.	*Per cent.*
Moisture	10·1	9·6
Calculated on the dry fibre:		
Ash	0·7	0·8
α-Hydrolysis, loss	11·3	11·3
β-Hydrolysis, loss	13·6	14·8
Acid purification, loss	2·3	2·1
Loss on washing in water	2·6	—
Cellulose	76·7	77·4

The fibre was submitted for valuation to a firm of merchants, who valued it at £96 per ton in London (August 1917); the pre-war value would have been £27 to £28 per ton.

Sisal hemp of this quality would be readily saleable. The merchants who valued the sample stated that it was equal to prime British East Africa fibre, and expressed a desire to procure supplies if possible. Information has therefore been requested by the Imperial Institute as to whether shipments of the fibre can be made later on from British Honduras.

Belgian Congo

A specimen of Sisal hemp was included in the series of fibres from the Belgian Congo referred to on p. 488.

The sample consisted of fairly lustrous, moderately coarse straw-coloured fibre. It was clean and well prepared, except for a little uncleaned fibre at the butt-ends, but the colour was somewhat uneven. The fibre was of good strength and varied in length from 2½ to 4½ ft., the average being 3 to 3½ ft.

The results of chemical examination of this fibre compared with those of Sisal hemp from Nyasaland are shown in the following table:

	Present sample.	Fibre of *A. rigida* from Nyasaland.
	Per cent.	*Per cent.*
Moisture	9·5	9·2
Calculated on the dry fibre:		
Ash	1·1	0·5
α-Hydrolysis, loss	14·8	8·6
β-Hydrolysis, loss	15·9	11·1
Acid purification, loss	2·2	0·4
Loss on washing in water	2·0	—
Cellulose	74·8	80·9

The fibre was valued by merchants in London at £60 per ton (May 1917).

This sample of Sisal hemp was not of good quality. The losses on hydrolysis are somewhat high, and the percentage of cellulose is rather low for Sisal hemp. The fibre is inferior in lustre, colour and coarseness to the sample previously sent from the Belgian Congo (see this BULLETIN, 1916, **14**, 386), and on the whole it is more like Furcræa fibre than Sisal hemp, and it is desirable that its exact origin should be investigated.

FIBRES FROM THE BELGIAN CONGO—II

IN a previous number of this BULLETIN (1916, **14**, 385) an account was given of the results of examination at the Imperial Institute of a series of fibres from the Belgian Congo, including baobab bark (*Adansonia digitata*, Linn.), punga bark (*Cephalonema polyandrum*, K. Schum.), and several Agave and Furcræa fibres. In December 1916 a further set of fibres from the Belgian Congo was received from the Belgian Minister of the Colonies. They were derived from the following plants: *Agave rigida* var. *sisalana* (Sisal hemp), *Sansevieria cylindrica* and *S. guineensis* (bowstring hemp), *Furcræa gigantea* (Mauritius hemp), *Musa textilis* (Manila hemp), *Manniophyton africanum*, *Boehmeria nivea* (ramie) and *Arenga saccharifera*. The first of these samples (Sisal hemp) is dealt with on p. 487 of this BULLETIN, and the others are described in the following pages.

Sansevieria fibres

The leaves of several species of *Sansevieria* yield the fibre known as bowstring hemp, the chief being *S. Ehrenbergii* of East Africa, *S. guineensis*, which occurs in West and East Africa, and *S. cylindrica*, which occurs in Africa from Zanzibar in the east to Angola in the west. *S. Roxburghiana* is an Indian species which yields "murva" fibre. The fibres are used in cordage manufacture and resemble Sisal hemp in general properties. Prior to the outbreak of war, fairly steady supplies of Sansevieria

fibre from German East Africa were coming on the London market and found a regular outlet.

The fibres received from the Belgian Congo were prepared from *S. cylindrica* and *S. guineensis*.

No. 1. *Sansevieria cylindrica.*—The sample consisted of well-prepared, fairly fine fibre, of pale straw colour and fair lustre. The butt-ends were insufficiently cleaned. The fibre was of fair strength and varied in length from 30 to 40 in., the average being 33 in.

The results of chemical examination were as follows :

	Per cent.
Moisture	8·5
Calculated on the dry fibre :	
Ash	0·4
α-Hydrolysis, loss	9·0
β-Hydrolysis, loss	13·0
Acid purification, loss	1·1
Loss on washing in water	1·1
Cellulose	74·0

The fibre was valued by merchants in London at £75 per ton (May 1917).

This fibre was of good quality, and should be saleable at about the same price as Sisal hemp, or somewhat less.

No. 2. *Sansevieria guineensis.*—The sample consisted of fine, pale straw-coloured fibre of good lustre. On the whole the fibre was well prepared; the butt-ends, however, were insufficiently cleaned. It was of good strength and the length varied from 2 ft. to 3 ft. 4 in., with an average of 30 in.

The results of chemical examination of the fibre, compared with those previously obtained at the Imperial Institute in the case of *S. guineensis* fibre from Sierra Leone, are shown below.

	Present sample.	Fibre of *S. guineensis* from Sierra Leone.
	Per cent.	Per cent.
Moisture	9·2	10·6
Calculated on the dry fibre :		
Ash	0·9	0·4
α-Hydrolysis, loss	10·4	8·9
β-Hydrolysis, loss	13·7	13·9
Acid purification, loss	2·0	1·8
Loss on washing in water	0·4	—
Cellulose	76·5	78·0

The fibre was valued by merchants in London at £78 to £80 per ton (May 1917).

The fibre was of normal character and resembled previous samples of *S. guineensis* fibre examined at the Imperial Institute (cf. this BULLETIN, 1903, 1, 22; 1906, 4, 190, 192; 1907, 5, 111; 1908, 6, 240). It could have been improved by paying more attention to the cleaning of the butt-ends of the leaves, and it would probably be advantageous to grade the long and short fibres separately.

Mauritius Hemp

Two samples of fibre obtained from the leaves of *Furcraea gigantea*, which yields the Mauritius hemp of commerce, were received.

No. 1.—This was of uneven straw colour and of varying lustre, but on the whole it was well cleaned and prepared. The strength of the fibre was uneven, but on the whole good. The length varied from 2 to 7 ft. with an average of about 5 ft.

No. 2.—This consisted of a pale straw-coloured, lustrous, coarse fibre, fairly well cleaned and prepared and similar in general appearance to sample No. 1. Some of the leaves had been incompletely cleaned at the butt-ends. The fibre was of very good strength, and varied in length from 3 to 5 ft. with an average of about 4 ft.

The two samples were examined chemically, with the results given in the following table, which also shows the corresponding figures obtained at the Imperial Institute in the case of a specimen of *F. gigantea* fibre from Nyasaland.

	Present samples. No. 1.	No. 2.	Fibre of *F. gigantea* from Nyasaland.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	8·6	8·3	8·7
Calculated on the dry fibre:			
Ash	1·0	0·5	1·1
α-Hydrolysis, loss	13·5	9·2	10·0
β-Hydrolysis, loss	19·0	12·5	14·5
Acid purification, loss	1·0	1·3	1·7
Loss on washing in water	1·2	0·6	—
Cellulose	74·5	80·3	75·8

Sample No. 1 was valued by merchants in London at £85 per ton, and sample No. 2 at £80 to £81 per ton (May 1917).

Sample No. 1 was inferior in colour and lustre to a previous sample from the Belgian Congo (see this BULLETIN, 1916, **14**, 387), but it was a coarser fibre, more like Sisal hemp, and if better prepared would have represented a good type of Furcræa fibre. It is desirable that the short and long fibres should be baled separately before shipment.

On the whole sample No. 2 was somewhat coarser than sample No. 1, and judging from its appearance and chemical composition it was superior in quality. It was, however, inferior in colour and lustre to the sample previously sent (*loc. cit.*), and could have been improved by more careful preparation.

Musa textilis

This sample consisted of light-brown, clean, well-prepared fibre of good lustre. It was of rather uneven strength, and on the whole weak and brittle, and varied in length from 4 to 5 ft., with an average of 4 ft. 6 in.

The following table shows the results of chemical examination of the fibre compared with a specimen of Standard Manila hemp:

	Present sample. *Per cent.*	Standard Manila hemp. *Per cent.*
Moisture	8·5	10·2
Calculated on the dry fibre:		
Ash	0·9	1·1
α-Hydrolysis, loss	11·8	11·2
β-Hydrolysis, loss	21·0	17·8
Acid purification, loss	2·4	1·6
Loss on washing in water	1·8	—
Cellulose	75·0	78·6

The fibre was valued by merchants in London at £35 to £40 per ton (May 1917).

The results of the chemical examination of this sample are normal for Manila hemp, but the material was of poor strength and resembled "Pacol" or wild banana fibre in quality.

Manniophyton africanum

M. africanum, Müll. Arg., is a shrub or woody climber reaching a length of 30 ft. It belongs to the Natural

Order Euphorbiaceæ and is confined to tropical West Africa. The bark is utilised by natives in the Belgian Congo, where the plant is known as "N'kossa," for the preparation of a strong fibre used for making fishing lines. Four samples of this fibre were received from the Belgian Congo, as follows:—

No. 1.—"*Manniophyton africanum* obtenu par battage et rouissage pendant 6 jours." The sample consisted of partially prepared bark fibre, which was harsh and gummy and would only be suitable for making coarse rope. The matted strands of fibre measured from 2 to 4 ft. in length, with an average length of 3 ft., and were of a greyish-brown colour. The strength of the fibre was very good.

The bark was composed of lignified fibre, the ultimate fibres of which measured from 9·2 to 20·0 mm. in length, with an average of 14 mm., and from 0·015 to 0·03 mm. in diameter with an average of 0·02 mm. The fibres were long and smooth, with pointed ends.

No. 2.—"Fibre de *Manniophyton africanum* battue et peignée sans rouissage. Même échantillon que No. 1." This sample was of cream colour, and stiffer than No. 1, but otherwise showed the same general characteristics.

No. 3.—"*Manniophyton africanum* préparé par méthode indigène. Même échantillon que Nos. 1 and 2." This sample was brown in colour, and exhibited the same characteristics as Nos. 1 and 2.

No. 4.—"Fibre de *Manniophyton africanum* IV." Although rather harsh and gummy, this sample was better prepared than Nos. 1, 2 or 3. It was, however, dark brown in colour, and possessed no lustre.

All four samples consisted of partially prepared bark fibre, and would be unsuitable for export to Europe in their present condition, as they would only be suitable for making very coarse ropes. Attempts were made at the Imperial Institute to de-gum the fibres by treatment with dilute alkaline solutions, and a fairly clean, fine but weak fibre was thus obtained. Unless a good strong, clean fibre can be prepared by retting, it seems unlikely that the material would prove of value in Europe.

Boehmeria nivea (*Ramie*)

This sample consisted of a greyish fibre, which was fine and soft, and of fair lustre where it had been thoroughly prepared. For the most part the fibre was of poor lustre, and a little stiff and harsh owing to the presence of gum. The length varied from 3 to 4 ft., and the strength was very uneven, probably owing to the method of preparation, as the parts of the sample free from gum were weak, whilst the gummy parts were strong.

Ramie fibre as represented by this sample would probably not be readily saleable in Europe, as manufacturers prefer to de-gum the fibre themselves. In the form of scraped ribbons similar to those of commercial "China grass" it should, however, be saleable.

Arenga saccharifera

A. saccharifera, Labill., the sago palm of Malacca and Malaya, is commonly cultivated in India, mainly as a source of palm sugar and wine, and it has been introduced into most tropical countries. A black fibre, known as "ejow" or "eju" fibre, which is extensively used in the East, is obtained from the base of the petiole. According to Morris (*Journ. Roy. Soc. Arts*, 1895, **45**, 931), three qualities are obtained: (1) a coarse fibre suitable only for brush-making, (2) a medium quality, closely resembling black horse-hair and used for making ropes and cables, and (3) the finest fibre, used for caulking ships, as a stuffing material for cushions, and as tinder.

A specimen of the fibre received from the Belgian Congo consisted of dull brownish-black fibre, which was rather brittle. It contained a fair proportion of dust and vegetable debris. The fibres measured from 10 to 34 in., being mostly about 14 or 15 in. long; and were from 0·004 to 0·02 in. (average about 0·008 in.) in diameter.

The fibre was forwarded for valuation to a firm of brokers in London, who submitted it to manufacturers of curled hair, bedding manufacturers, and brush makers, with the following results:

(*a*) The curled-hair manufacturers stated that if fibre

of the quality of the sample could be supplied in bulk it could be used for curling purposes, but that it was not possible to assign a definite value to it under present conditions. The firm suggested £25 per ton as a possible price, but could not bind themselves in any way to this figure.

(*b*) The bedding manufacturers stated that the material was similar to a Madagascar fibre at present selling at about £14 per ton ex warehouse in London. They considered that fibre similar to the present sample could be used as a "first stuffing" in upholstery. The firm added that the market value of the fibre would depend largely on the method of packing, and they suggested that it might be loosely pressed in 1 cwt. bales, preferably by means of a hand press, as hydraulic pressing might be injurious.

(*c*) The brush makers considered that the longer fibres, if dyed, could be mixed with horse-hair for brush-making purposes, and that the short "combings" would be suitable for mixing with curled hair. They were of opinion that if well dyed and cleaned the fibre should prove very useful for these purposes.

The brokers who submitted the material to the above-mentioned firms suggested that it would be desirable to forward a trial shipment of this Arenga fibre from the Belgian Congo for sale in London, as this would enable technical trials to be carried out, and the industrial value of the fibre to be definitely determined.

COPAL FROM COLOMBIA

THE sample of copal which is the subject of this report was forwarded to the Imperial Institute by the Director of the Tropical Agricultural Station, San Lorenzo, Colombia, in September 1916.

It was stated that the copal, which is known locally as "ambara" or "algarrovillo," had been previously exported to some extent to Germany, and it was considered that there should be a ready sale for it in the United Kingdom. It was further mentioned that the material was supposed to be derived from *Hymenœa*

splendida, a close relative of the tree which yields Demerara animi (*H. Courbaril*).

The copal as received was in the form of pale brownish-yellow irregular pieces, some of which enclosed earthy material and drops of liquid. The pieces were coated with a weathered crust, but were transparent and broke with a glassy fracture.

An average sample of the copal, freed by hand from obvious impurities, was submitted to chemical examination with the following results :

Moisture	*per cent.*	0·52
Ash	"	0·09
Melting point		123° C.
Acid value [1]		100·8
Saponification value [1]		103·6
Loss on "melting"	*per cent.*	18·0

[1] *Milligrams of caustic potash required to neutralise* 1 *gram of copal.*

The copal was very slightly soluble in ether, chloroform, benzene or turpentine oil ; almost insoluble in a mixture of benzene and turpentine oil ; and partially soluble in alcohol and in mixtures of alcohol and ether, alcohol and benzene, and alcohol and turpentine oil.

One part of the "melted" copal dissolved in one part of turpentine oil produced a reddish-brown varnish, which gave on sized wood a pale yellow hard coat of good lustre.

Samples of the copal were submitted to two firms of varnish manufacturers with the following results :

(1) One firm stated that the material corresponded to Demerara animi derived from *Hymenœa Courbaril*, and that it would be suitable for use in the manufacture of various grades of decorative oil varnishes. The firm considered the present commercial value of the copal in the United Kingdom in the uncleaned and unsorted condition to be £70 to £90 per ton, and if cleaned and sorted £120 to £160 per ton (June 1917).

(2) A second firm stated that judging from appearances the material is a high-class copal gum, and if properly scraped would be suitable for use in varnish manufacture. They expressed a desire to be furnished with a quantity of about 56 lb. for practical trial on a factory scale

The appearance of this copal could have been improved and its value enhanced by the usual process of cleaning, *i.e.* soaking in dilute caustic soda, followed by brushing to remove the weathered crust, and by the removal of dark-coloured pieces or those showing impurities.

Information is being sought by the Imperial Institute from the authorities in Colombia as to the possibility of forwarding shipments and the quantities available.

WATTLE BARK AND WOOD

For some years before the war the Imperial Institute on many occasions directed attention to the fact that whilst the British market was largely supplied by tanning materials derived from the Continent, large quantities of tanning materials produced in other countries of the Empire found their chief market on the Continent instead of in the United Kingdom. On the outbreak of war, tanners in this country found some of their usual sources of supply of tanning materials cut off and at the same time the Continental markets for tanning materials produced within the Empire were no longer open. In these circumstances the Imperial Institute took the opportunity of again calling the attention of British tanners to wattle bark, of which large supplies are produced in South Africa, which had before the war been disposed of chiefly in Germany. A special circular was prepared and distributed to British tanners and to British firms engaged in the importation of tanning materials.

There was a good response to this circular; a number of firms began using the bark, and have continued to do so, with the result that far larger quantities of the bark are now being used in this country than before the war. In addition, the manufacture of wattle bark extract has been undertaken in South Africa as well as in this country, and this extract finds a ready market in the United Kingdom.

The action of the Imperial Institute also had important results in Russia, where publicity has been given

to a translation of the circular, no less than 6,505 tons of the bark having been shipped direct from Natal to Russia in 1916.

Production of Wattle Bark in the British Empire

Wattle barks are derived from several species of Acacia, which are indigenous to Australia, and have been introduced into South and East Africa, where they are grown in plantations. The best known as a tanning material in Europe is the bark of the black wattle (*Acacia decurrens* var. *mollissima*).

South Africa.—The production of wattle bark is an industry of the greatest importance to South Africa, especially to the Province of Natal, and one which is rapidly increasing in magnitude. The area under wattle in Natal at the end of 1916 was estimated to be about 160,000 acres.

The following statement shows the exports of wattle bark from the Union of South Africa and the approximate average price for chopped bark in London during the past eleven years. The figures quoted show that the price of the bark gradually declined as the supplies increased, up to the outbreak of the war, but since that date the price has risen considerably owing chiefly to the scarcity of freight.

Year.	Exports from South Africa.	Average price per ton.			Year.	Exports from South Africa.	Average price per ton.		
	Tons.	£	*s.*	*d.*		*Tons.*	£	*s.*	*d.*
1906	14,828	9	0	0	1912	52,776	7	5	0
1907	24,321	8	10	0	1913	65,052	7	5	0
1908	24,849	8	2	6	1914	58,132	7	12	6
1909	35,771	8	10	0	1915	40,027	8	10	0
1910	41,344	8	2	6	1916	50,867	13	10	0
1911	49,645	8	7	6					

During the past two years the price has fluctuated considerably. In 1916 the highest quotation in London was £17 and the lowest £13 per ton. During 1917 the prices ranged from £13 7*s.* 6*d.* to £22 10*s.* per ton.

The following table shows that a much larger proportion of the wattle bark imported into the United

Kingdom from Natal is utilised in this country than was formerly the case:

Imports of Tanning Bark into the United Kingdom from Natal

	1913. Tons.	1914. Tons.	1915. Tons.	1916. Tons.
Total imports	40,561	36,128	34,110	23,364
Retained in the United Kingdom	7,943	8,672	22,412	17,432

The trade returns of the Union of South Africa show that, in 1916, after the United Kingdom, the United States, Russia, Australia, India and Japan were the chief countries to which wattle bark was exported.

The manufacture of wattle bark extract is being carried on to an increasing extent in Natal. Exports of the extract amounted to 438 tons in 1916, the whole of which was shipped to the United Kingdom. In the first ten months of 1917 943 tons of extract were exported.

Further particulars regarding the Natal industry and manufacture of extract will be found in this BULLETIN (1916, **14**, 599).

Australia.—The following statement shows the exports of "tanning bark" from the Commonwealth of Australia during recent years. The term "tanning bark" includes barks other than wattle bark, so that the exports of wattle bark cannot be exactly stated. A certain quantity of wattle bark is imported into the Commonwealth from South Africa, as noted above.

Year.	Quantity. Tons.	Value. £
1911	12,619	103,971
1912	7,884	67,525
1913	7,106	59,393
1914 (first six months) . . .	3,513	28,498
1914–15 (July–June) . . .	3,871	31,941

Quotations for Australian ground wattle bark in London varied during 1917 from £12 to £18 per ton, but were mostly nominal owing to absence of supplies consequent upon freight difficulties. The chief sources of the Australian bark are the golden or broad-leaved wattle (*A. pycnantha*) and the black wattle (*A. decurrens* var. *mollissima*).

East Africa Protectorate.—The exports of wattle bark from the East Africa Protectorate have not up to the

present been large, the highest figure reached being 202 tons, valued at £1,917 in 1913–14. Since that year, exports have been considerably curtailed by the war. The area planted with wattle in the Protectorate is stated to be over 12,000 acres.

Uses of Wattle Bark and Extract

The average amount of tannin in commercial wattle bark is 32 per cent. Thick wattle bark is almost invariably richer in tannin and of better colour than thin bark and realises better prices.

The bark is used chiefly for the production of heavy leathers, but it furnishes a full soft leather with calf-skin and might well be used for the production of light leathers. Leather tanned with wattle bark has a faint reddish tinge and the colour darkens slightly on continued exposure to light, but not more so than that of leather tanned with oak or hemlock bark or extract.

There is an increasing tendency among British tanners to use concentrated tanning extracts in place of barks and other tanning materials in their natural condition. The wattle bark extract now being manufactured both in this country and in Natal contains about 60 to 65 per cent. of tannin.

For more detailed information regarding wattle bark, the articles on "The Production and Utilisation of Wattle Bark" (this Bulletin, 1908, **6**, 157) and "The Utilisation of Wattle Bark" (*ibid.*, 1911, **9**, 116) may be consulted. The former contains analyses of wattle barks made at the Imperial Institute, and further analyses are given in subsequent numbers (1910, **8**, 245; 1913, **11**, 402).

Utilisation of Spent Wattle Bark and Wattle Wood

The increased employment of wattle bark in this country and the manufacture of the extract in South Africa made it desirable to consider the best methods of disposing of the spent material, remaining after the use of the bark either for tanning or for the production of extract. Experiments carried out at the Imperial Institute have shown that the material could be used for

the production of paper, and this result has been confirmed by a large scale trial conducted by a well-known firm of paper manufacturers. The question of the utilisation of wattle wood has also received attention, and the results of distillation trials carried out on black wattle wood from the East Africa Protectorate have already been given in this BULLETIN (1916, **14**, 570). The yield of acetate of lime (used in the preparation of acetone), wood spirit, tar and charcoal indicated that black wattle wood should be at least as profitable to distil as oak wood. Paper-making trials with the wood have also been made, the results of which, together with those obtained with the spent bark, are given in the following pages.

Paper-making Trials with Spent Wattle Bark

The extracted or spent wattle bark used in these trials was received from the East Africa Protectorate in August 1916. The material as received was found to contain 11·5 per cent. of moisture, 41·2 per cent. of cellulose, and 8·7 per cent. of ash. On extraction with hot water the bark lost 7·0 per cent. by weight. The ultimate fibres of the material measured from 1·0 to 2·2 mm. and were mostly about 1·7 mm. in length.

The extracted bark was examined as a paper-making material, using the soda process, with the following results:

Experiment No.	Caustic soda used.		Conditions of boiling.		Parts of soda consumed by 100 parts of bark.	Yield of dry unbleached paper pulp, expressed on the material as received.
	Parts per 100 parts of bark.	Parts per 100 parts of solution.	Time in hours.	Temperature.		*Per cent.*
1	20	4	4½	140° C.	14	28
2	16	4	4	140° C.	14	34
3	12	4	4	140° C.	all consumed	35

When treated under the conditions of experiment 2 the bark was sufficiently boiled to beat easily, and gave a dark brown pulp which yielded a fairly soft, opaque paper, of fair strength and quality, which did not shrink appreciably on drying. The pulp bleached readily to a cream colour.

The pulp from experiment 3 was not sufficiently boiled and the fibres were not completely separated even after long beating. Such long-fibred pulp has been recommended as a material for the production of roofing felt.

The treatment used in experiment 2 appears to be the most suitable for the preparation of "half-stuff" from this extracted wattle bark.

Although the yield of unbleached pulp from this extracted wattle bark is somewhat low, the material is fairly promising as a source of pulp for the production of brown paper, and may be suitable for the cheaper grades of white or cream papers such as newspaper.

As large quantities of spent wattle bark were becoming available in the United Kingdom owing to the increasing use of wattle bark by British tanners, it appeared desirable to have large scale trials made with the material by paper-makers.

Three tons of the spent bark were therefore obtained from a firm of tanners and submitted to paper-manufacturers for technical trials. The manufacturers reported that the dry bark furnished from 28 to 30 per cent. of pulp, which would be quite suitable for the manufacture of brown paper. The paper made entirely from the spent wattle bark under manufacturing conditions was regarded by the manufacturers as a very satisfactory wrapping paper of good strength and excellent folding qualities.

Arrangements are now being made by the Imperial Institute with makers of brown paper in the United Kingdom to utilise the supplies of the spent bark, which are becoming available from the tanneries.

Further enquiries are also being made as to the possibility of utilising the pulp, after bleaching, for the production of cheap grades of cream or white paper.

Paper-making Trials with Black Wattle Wood

In view of the promising results obtained with spent wattle bark as a paper-making material (see above), it seemed desirable to ascertain whether the wood could also be utilised for the same purpose, either alone or in

conjunction with the bark. The material employed in these trials consisted of black wattle wood from the East Africa Protectorate.

The wood was found to yield 61 per cent. of cellulose and 0·5 per cent. of ash, expressed on the dry material. The ultimate fibres measured from 0·8 to 1·1 mm. in length.

The wood was converted into pulp by the soda process with the following results :

	Caustic soda.		Conditions of boiling.		Parts of soda consumed by 100 parts of wood.	Yield of dry unbleached pulp, expressed on the wood as received.
	Parts per 100 parts of wood.	Parts per 100 parts of solution.	Time in hours.	Temperature.		*Per cent.*
A	16	4	4	140° C.	11	46
B	14	4	7	140° C.	10	50

The wood yielded a clean pulp of light brown colour, giving an opaque paper, which did not shrink on drying, but was lacking in strength, owing to the shortness of the ultimate fibres.

The conditions employed in experiment A produced a pulp of lighter colour than that obtained in experiment B. The pulp did not bleach well in either case, but that from experiment A bleached better than that from B.

With a view to ascertaining whether the sulphite process would give better results, the wood was also treated by this method, with the following results :

Strength of sulphite liquor.		Conditions of boiling.		Yield of dry unbleached pulp, expressed on the wood as received.
100 parts contained the equivalent of : Lime (CaO).	Magnesia (MgO).	Time in hours.	Temperature.	*Per cent.*
0·7	0·3	7	150° C.	48

As is generally the case, this process produced a pulp of much lighter colour than the soda process. The unbleached pulp was of light greyish-brown colour and it bleached easily to a creamy white tint. The paper was similar in strength to that produced by the soda process.

A large firm of paper manufacturers, who were con-

sulted by the Imperial Institute as to the possibility of utilising wattle wood in the paper-making industry, expressed the opinion that it could be used for making "straw-board" for which there is likely to be a large demand in the future for packing purposes. The firm considered that a mixture of 50 per cent. of wattle wood and 50 per cent. of spent wattle bark should furnish a satisfactory "straw-board."

The foregoing results show that black wattle wood gives a very fair yield of pulp, but that owing to the shortness of the ultimate fibres, the paper produced from it is of rather poor strength. It should, however, be possible to utilise the pulp for the manufacture of "straw-board," especially in conjunction with other materials of longer fibre, such as spent wattle bark pulp.

This possibility of using a mixture of wattle wood and spent wattle bark for the manufacture of straw-board will be of great importance in South Africa and Australia where large quantities of both materials are available, and where there is also a large demand for straw-board for packing fruit and for other purposes.

GENERAL ARTICLES

THE PEAS AND BEANS OF COMMERCE

The edible seeds of leguminous crops, such as beans, peas and lentils, included under the general term pulse, undoubtedly come next in range and importance to cereals, the grain produced by plants of the grass family. Wherever agriculture is practised, either in tropical or temperate countries, some kinds of leguminous crops are grown. In some cases these crops serve as green manure or as fodder for cattle, in others the fresh green pods are utilised as vegetables, but the most important product commercially is the seed. It is well known that leguminous crops enrich the soil in which they have been grown in nitrogen, hence they are of great value for rotation purposes.

Several distinct genera of plants, including a number

of species, are concerned in the production of commercial pulses, and most of the species have, under cultivation, given rise to numerous varieties that differ from each other in constitution and habit of growth, and most markedly in the colour, size and shape of their seeds. With regard to nomenclature, several common names are applied to the same plant when grown in different countries, and in commerce the seeds are frequently known by a name distinct from that applied to the plants that produced them; on the other hand the same name may be applied to seeds that bear a general resemblance to each other, but which are the produce of plants that are botanically distinct.

Chief Leguminous Crops cultivated for their Seed

The following is a list of the principal leguminous plants that are cultivated as crops chiefly for the sake of their seed in both tropical and temperate countries:

Botanical Name.	Common Name.
Arachis hypogaea, Linn.	Ground nut, earth nut, pea nut (U.S.A.), monkey nut, goober.
Cajanus indicus, Spreng.	Pigeon pea or bean, Angola pea, Congo pea, Dál (India), Bombay tares.
Canavalia ensiformis, DC.	Sword bean, over-look bean, cut-eye bean (W. Indies), horse beans (Montserrat), Go-ta-ni bean (E. Africa).
Cicer arietinum, Linn.	Gram, Bengal gram, chick pea, Spanish pea, Garbanzo (Spain).
Cyamopsis psoralioides, DC.	Cluster bean, Guar bean (India).
Dolichos biflorus, Linn.	Horse gram, Madras gram, Kulthi (India).
Dolichos Lablab, Linn.	Indian bean, Lablab bean.
Ervum Lens, Linn.	See *Lens esculenta*, Moench.
Faba vulgaris, Moench.	See *Vicia Faba*, Linn.
Glycine hispida, Maxim.	Soy bean, soja bean.
Lathyrus sativus, Linn.	Chickling vetch, vetchling, grass pea, Indian pea, mutter or mattar pea, Khesari (India).
Lens esculenta, Moench.	Lentil.
Phaseolus aconitifolius, Jacq.	Moth bean.
Phaseolus angularis (Willd.), W. F. Wight	Adzuki or Azuki bean (Japan).
Phaseolus calcaratus, Roxb.	Rice bean.
Phaseolus lunatus, Linn.	Lima or Duffin bean, Rangoon bean, Madagascar bean, butter bean.
Phaseolus Mungo, Linn.	Black gram, Urd (India).
Phaseolus radiatus, Linn.	Green gram, Mung (India).
Phaseolus vulgaris, Linn.	Dwarf bean, French bean, kidney bean, haricot bean.

Botanical Name.	Common Name.
Pisum arvense, Linn.	Field pea, grey pea, dun pea, partridge pea, maple pea, blue pea, Bara mattar (India).
Pisum sativum, Linn.	Common or garden pea.
Vicia Faba, Linn.	Broad bean, Windsor bean, horse bean, field bean.
Vigna Catjang, Walp.	Black-eye cow pea, cherry bean, cow pea, Chowlee, Lobia (India), Tow Cok (China), Faggliola del Occhio (S. Europe).
Voandzeia subterranea, Thouars.	Bambarra ground nut, Mozambique gram, Madagascar earth nut.

Although eaten as pulses in the countries where they are grown, ground nuts and soy beans are valued in Europe chiefly as oil seeds, and they will therefore not be dealt with in this article. Information regarding them has already been given in this BULLETIN (ground nuts, 1910, **8**, 153; soy beans, 1909, **7**, 308 and 1910, **8**, 40).

The seeds of certain of the leguminous plants mentioned in the list given above are of importance only in the countries where they are produced, and they do not enter into European commerce on a large scale; such, for instance, are the sword bean (*Canavalia ensiformis*), the cluster or Guar bean (*Cyamopsis psoralioides*), the Lablab bean (*Dolichos Lablab*), and the Bambarra ground nut (*Voandzeia subterranea*). These pulses have, however, a certain value as feeding stuffs for animals, and also as human food, and a market for them may eventually be developed in Europe.

Samples of "sword beans" received from the Gold Coast, Honduras, Montserrat and Burma have been examined at the Imperial Institute, and no deleterious constituents have been found in them, although in some countries where they are grown they are regarded with suspicion as being harmful (see this BULLETIN, 1913, **11**, 242; 1914, **12**, 549, 550; 1915, **13**, 192), apparently on no very good ground. Since the war samples of a variety of Canavalia known as the Go-ta-ni bean have been received from British East Africa. The seeds of the cluster or Guar bean are said to be used in India as food for animals as well as for human consumption.

Lablab beans (*Dolichos Lablab*) are largely grown in China and in India and also in other tropical countries. A report on samples received from Hongkong that were

examined at the Imperial Institute appeared in this BULLETIN (1912, **10**, 235). The Bambarra ground nut has also been examined at the Imperial Institute, and although no harmful constituents could be detected, it was not highly valued by merchants at that time. (See this BULLETIN, 1909, **7**, 151; 1914, **12**, 344.) The great drawback to these pulses is that they are not known, and it is always a difficult matter to find a market for unknown food-stuffs, especially beans, new varieties of which are usually regarded with suspicion. The present scarcity of food-stuffs is, however, resulting in the introduction into this country for human food of a number of new kinds of pulse, to some of which allusion is made below.

The scarlet runner bean (*Phaseolus multiflorus*) is grown mainly for the sake of its green immature pods, but the ripe seeds are occasionally eaten as a pulse.

Commercial Pulses

By far the most important pulses commercially are the various kinds of peas and beans that serve as food-stuffs for animals and also for human consumption. The chief countries that export peas in normal times are India, Russia, Japan, China and the Netherlands. The principal countries exporting beans are China, India, Turkey, Russia and Egypt. The beans used for human consumption and known in British commerce under the general name of "haricots," though many of them are not true haricots (see p. 507), are derived chiefly from Madagascar, India (Burma), France, Rumania, Japan, Germany and Chile.

The trade of the United Kingdom in pulses is, in normal times, sharply divided into two sections, viz.:

(1) Pulses utilised as human food.

(2) Pulses utilised as cattle food.

(1) The pulses utilised as human food include the following:

(*a*) Haricot beans, white and coloured (*Phaseolus vulgaris*).

(*b*) Madagascar butter beans, Lima beans and Rangoon white beans (*Phaseolus lunatus*).

(*c*) Green peas, smooth and wrinkled varieties (*Pisum sativum*).

(*d*) Yellow peas, smooth and wrinkled varieties (*Pisum sativum*).

(*e*) Yellow peas and off-coloured green peas (*Pisum sativum*) and field peas (*P. arvense*), split or ground into meal or flour.

(*f*) Chick peas or Spanish peas, white kinds (*Cicer arietinum*).

(*g*) Lentils, whole or split (*Lens esculenta*).

(*h*) Japanese " Adzuki " or Chefoo red beans (*Phaseolus angularis*) and other small beans produced by species of Phaseolus.

(2) The pulses utilised for cattle food include the following :

(*a*) Dun peas, maple peas, partridge peas, grey or field peas (*Pisum arvense*).

(*b*) Broad beans and horse beans (*Vicia Faba*).

(*c*) Pigeon peas or beans (*Cajanus indicus*).

(*d*) Horse gram (*Dolichos biflorus*).

(*e*) Bengal gram, or chick peas (coloured kinds) (*Cicer arietinum*).

(*f*) All other kinds of coloured beans, including red Rangoon beans (*Phaseolus lunatus*).

Haricot Beans and Butter Beans

Various kinds of beans are known in British commerce as haricots, including the seeds of *Phaseolus vulgaris*, the dwarf French or kidney bean, to which the term is more correctly applied, and the seeds of certain varieties of *P. lunatus*. Butter beans are furnished by other varieties of the latter species.

True Haricot Beans

Phaseolus vulgaris is largely grown in many countries for its seeds and also in European gardens for the sake of its young pods, which are used as a green vegetable. The plants of *Phaseolus vulgaris* are annual, erect and bushy (French beans), or in some varieties the branches are twining (kidney beans) ; the leaves are trifoliate on long stalks ; the flowers, produced in racemes, vary in colour from white or pink to purple. The seeds are extremely variable in size and also in shape and colour ;

they are usually long, kidney-shaped in profile and oval in cross section; but some are short and plump and nearly oval in profile. The colour of the seeds varies from white to jet black through various shades of yellow, brown and purple; they are also frequently speckled. Numerous varieties are known in gardens.

In some cases the pods are of a yellow colour whilst still in a young state, and these kinds are known in gardens as "butter" beans. They are, however, quite distinct from the "butter" beans of commerce, which are the seeds of a variety of *Phaseolus lunatus* (see p. 511).

Originally native to South America, *Phaseolus vulgaris* is susceptible to frosts, and the crop can therefore only be produced during summer in temperate countries. Two or three crops a year are possible in warm countries.

French or kidney beans succeed best on soils in a good state of fertility, although fair crops may sometimes be obtained from poor soils. Fairly light soils that have been well cultivated and manured for a previous crop are the most suitable to employ. In warm countries the twining varieties are frequently intercropped with maize, the stems of the latter furnishing the necessary support for the beans.

Varieties and Sources of True Haricot Beans

Prior to the outbreak of war British supplies of true haricot beans were obtained chiefly from European countries, Rumania, Germany, Austria-Hungary, Belgium, Italy and France furnishing the bulk of the supplies. These beans were chiefly white kinds, such as "White Italian," "White Soissons" and "White Danubian," which in this country are generally preferred to coloured kinds for human consumption as they have a better appearance when cooked. The coloured forms of true haricots have, however, no harmful constituents, and are preferred in some cases as they have a thin skin and a more agreeable flavour than some of the white kinds. Such varieties as "Rose Cocos" (speckled), "Canadian Wonder" (purple) and "Burlotti" (speckled) are commonly imported. Since the war a brown variety, which is said to be superior in flavour to the white forms, has been introduced into this

country for cultivation from Holland by the Royal Horticultural Society. These beans, known as "Dutch Brown," are small, oval in profile, almost circular in cross section and of a light coffee-brown colour.

In tropical South American countries beans form to a great extent the staple food of the people and are grown in large quantities. Before the war it was sometimes necessary for these countries to import beans to supplement the local crop, but during the past few years there has been a large export to Europe.

The following table, quoted from the *U.S. Commerce Rept.* No. 218, 1917, illustrates the rapid growth of the export trade of beans in Brazil:

Exports of Beans from Brazil

	1914. *Kilos.*	1915. *Kilos.*	1916. *Kilos.*	1917 (1st five months). *Kilos.*
Total	4,441	276,159	45,593,944	53,084,331
To				
United States	—	—	7,463,515	9,193,220
France	1,020	1,620	34,138,100	23,455,880
United Kingdom	—	138	1,851,600	18,284,913
Italy	181	210	1,023,240	1,001,175
Uruguay	660	120,052	977,680	925,620

1 *kilo.* = 2·204 *lb.*

The following is a list of the kinds of Brazilian beans imported into the United Kingdom during the past year, samples of which have been received at the Imperial Institute:

Grey.—Long, oval, ¾ in. long by ¼ in. broad, dark coffee-brown, with a darker tint round the prominent white hilum ("eye").

Praia.—Similar in size and shape to the preceding, of a buff ground colour heavily blotched with dull purplish-brown.

Cavallho.—Similar in size and shape to the preceding, of a rose-purple colour heavily blotched with a deeper tint.

Sulphur.—Similar in size and shape to the preceding, of a pale buff yellow with a brownish blotch round the hilum.

Meuro.—Small, oval, ½ in. long by ¼ in. broad, dull slaty brown in colour, speckled, with a darker line round the hilum.

Ciririca.—Similar to the preceding in size and shape, but more distinctly speckled and blotched.

Tupy.—Similar in size and shape to the preceding, of a light brown colour stained with rose-purple.

Mulatinho.—Slightly larger than the preceding, of a light coffee-brown colour.

Carioca A.—Similar in size and shape to the preceding, pinkish-brown, with irregular black markings.

Carioca B.—Larger than the preceding, ½ in. long by ¼ in. broad, of a pale buff colour, with irregular markings and blotches of rose-purple.

Carioca C.—Similar to *Carioca A*, but slightly larger.

Carioca D.—Similar in size and shape to *Carioca A*, of a buff colour heavily speckled with violet-purple.

Carioca E.—Oval, ½ in. long by ⅓ in. wide, pale buff yellow with irregular markings and blotches of dark brown.

Carioca F.—Similar in size and shape to *Carioca A*, of a dark coffee-brown to black colour.

Vinegar.—Plump oval beans, ½ in. long by ⅓ in. broad; uniform chestnut-brown with small white hilum.

Vinegar, dark.—Similar in size and shape to the preceding, but of a deep purple colour.

Canary.—Similar in size and shape to the preceding, of a sulphur-yellow colour, with a brown blotch surrounding the hilum.

Gold.—Similar in size and shape to the preceding, of a uniform golden-brown colour.

"Chilian white" beans, imported from Chile, are true haricots, resembling the "white Italian." The large white beans known as Lima beans or "butter" beans, imported from Peru, are the seeds of *Phaseolus lunatus*, and are not, therefore, true haricots.

Large quantities of beans are grown in Japan, and the export of haricot or kidney beans from Japan to the United Kingdom has assumed considerable proportions since the war began. The bean trade of Japan is not, however, confined to local produce, as the exports include large

quantities of soya beans, horse beans and haricot beans originally imported from Manchuria, North China and Korea. The centres of the Japan bean trade are at Kobé and Yokohama, where the beans are sorted, cleaned and put up into bags for shipment. The export of white haricot beans from Japan is of comparatively recent growth, but there is every indication that this trade will largely increase, as the soil of Japan is well suited to the production of this class of pulse, and there is an abundance of cheap labour available.

The following kinds of haricot beans, white and coloured, have been received on the London market from Japan during the past year:

Kotenashi.—Small, plump, oval beans, about the size of garden peas, of an ivory-white colour. These are known as small "Lady Washington" beans in the United States.

Chutenashi.—Similar to the preceding but slightly larger.

Otenashi.—Similar to the preceding but slightly larger and longer. These are known as large "Lady Washington" beans in the United States.

Chufuku.—Long, flat, kidney-shaped beans of a fine ivory-white colour.

Daifuku.—Similar to the preceding, but about twice the size.

Naga uzura or *Speckled Bayos.*—Long, kidney-shaped beans of a dun-yellow ground colour irregularly blotched with red.

Chunaga.—Oval-shaped beans of a buff-yellow ground colour blotched with brown.

Kintoki red.—Oval, plump beans of a uniform brownish-purple, with a small white hilum or "eye." These are known as "cranberry" beans in the United States.

Phaseolus lunatus Beans

Another species, *Phaseolus lunatus*, furnishes so-called haricot beans of commerce. This species is a twining plant with trifoliate leaves and short-stalked, many-

flowered racemes of greenish-yellow flowers; the pods are scimitar-shaped and usually contain three seeds. The seeds are variable in size, shape and colour, usually flattened, more or less rounded or kidney-shaped in profile, and from deep purple to red-brown or white in colour, and sometimes striped or blotched. All varieties of the seeds show vein-like lines radiating from the hilum (eye) to the outer rounded edge; these lines are usually strongly marked in the coloured forms, but appear only as faint veins in the white varieties.

Varieties and Production of Phaseolus lunatus Beans

Originally native to South America, *Phaseolus lunatus* was introduced to Southern California from the vicinity of Lima as early as the fifteenth century, and is now widely distributed in cultivation throughout the warmer parts of the world. Under cultivation the seed has become much plumper and the size has been much increased; the colour has also been changed from purplish-red to white (Lima or Duffin beans). Cultivated forms of Lima beans are said to have been introduced into Madagascar by traders about the year 1864. These beans were planted by the natives, and since the French occupation of Madagascar this crop has furnished an important article of export. The beans are known to Madagascar traders by the erroneous name of Cape peas or Pois du Cap, and on the London market as "butter" beans or Madagascar beans. These beans are of large size, flat and kidney-shaped, and of an ivory-white colour. The growth of the Madagascar trade in these beans is shown in the following table:

Exports of Pois du Cap or "Butter" Beans from Madagascar

Year.	Quantities. *Metric Tons.*	Value. £.
1906	1,237	17,165
1907	2,135	29,660
1908	2,533	34,963
1909	2,974	36,378
1910	3,513	46,429
1911	7,436	126,668
1912	6,073	112,303
1913	8,141	137,819
1914	8,561	140,415

In Madagascar this bean is said to receive but little cultivation. It is planted along the districts bordering the Onilahy river after the flood waters have subsided in March. Holes are made in the soft ground to receive the seeds, and two or three seeds are planted in each. The crop requires about six months to ripen its seeds, and during this period the plants receive no attention. The long twining stems are allowed to trail over the ground, and this is probably an advantage, as by so doing they shade the soil and prevent the too rapid evaporation of soil moisture, and at the same time the plants are less exposed to the hot drying winds which scorch other vegetation. The harvesting is done by hand, the ripe pods being plucked and thrown together in heaps and afterwards thrashed with a flail to obtain the beans.

Forms of *Phaseolus lunatus* are largely grown in Burma, more especially in the Sagaing, Pakokku, Mândalay, Lower Chindwin, Meiktila and Myingyan districts. The two most common forms grown in Burma are the red-seeded and the white-seeded kinds, known commercially as "Burma red beans" and "Burma white" or "Rangoon" beans, and locally as Pè-gya and Pè-byu-galè. The Rangoon or Burma white beans are much smaller than the Madagascar butter beans.

In Burma *P. lunatus* is a favourite crop for field cultivation, 240,000 acres being devoted to the white variety and 94,000 to the red in 1916–17. In the hill districts the seeds are usually sown at the beginning of the rains; in the plains they are sown from August to December. Seeds are usually dropped into furrows made by the native plough in rows about 1 to 1½ ft. apart; they are also sometimes broad-casted mixed with maize, and are covered with soil by harrowing. When sown with maize, the stems of the maize plants serve as supports to the trailing stems of the beans, but when sown alone, the stems are allowed to trail over the ground. The crop generally takes about five months to mature; the stems are then cut with a sickle and the thrashing is done in the ordinary native way by means of bullocks. A clayey loam rather than a sandy soil is preferred for this crop.

The extent of the bean trade of Burma is shown in the following table, which gives the quantities and values of pulse (including peas) exported from the Province overseas during the period 1909–10 to 1916–17:

Year.	Quantity. Cwts.	Value. £	To the United Kingdom. Cwts.
1909–10	361,912	99,415	178,292
1910–11	545,309	142,047	232,032
1911–12	576,352	165,665	235,961
1912–13	430,233	139,379	116,644
1913–14	492,071	143,136	119,340
1914–15	693,643	209,388	433,240
1915–16	732,554	280,532	625,760
1916–17	1,439,009	791,208	1,138,020

In addition to the above there is a large coasting trade in beans with peninsular India.

With a view to improving the type of bean grown in Burma for export, consignments of Madagascar "butter" beans have been forwarded to Burma by the Imperial Institute from time to time for trial cultivation. Samples of beans produced in Burma from the seed supplied have been forwarded to the Imperial Institute for examination, and the results of examination have been published in this BULLETIN (1914, **12**, 355; 1915, **13**, 196; 1916, **14**, 149). Other white beans are also under trial by the local Department of Agriculture, which is giving constant attention to the improvement of the bean crops.

Development of Prussic Acid in Phaseolus lunatus Beans

The subject of the development of prussic (hydrocyanic) acid from *Phaseolus lunatus* beans has been carefully studied at the Imperial Institute for several years. In the first instance beans produced in Mauritius by wild plants of *P. lunatus* were examined, and these were found to yield 0·1 per cent. of hydrocyanic acid. Just at the conclusion of this work large quantities of beans began to come on the British market from Burma; samples of these were submitted to the Imperial Institute by several merchants and importers for examination, and were found to yield only traces of hydrocyanic acid which were too small to be harmful.

In 1905, beans derived from wild *P. lunatus* plants appeared on the European markets from Java, under the trade name of Java beans, and these caused the death of a number of cattle in England, as well as of some human beings on the Continent. Samples of these beans were also examined, and were found to furnish quantities of hydrocyanic acid varying from 0·03 to 0·16 per cent.

There is a great difference between the poisonous beans produced in Java and Mauritius by wild plants of *P. lunatus* and those produced in Burma or elsewhere from the cultivated varieties of this species. Both the white and the red forms of Burma beans have been repeatedly examined. As a rule the white beans yield no prussic acid, but sometimes traces are present, and in one case as much as 0·02 per cent. was found. The red beans usually yield traces. In no cases have quantities of prussic acid which can be regarded as harmful been found at the Imperial Institute in Burma beans of either type, and, as shown by the table given on p. 514, the trade in these beans is now firmly established.

White cultivated types of *P. lunatus* from South America and Madagascar have also been examined and found to yield no hydrocyanic acid or mere traces. It is evident, therefore, that the beans derived from cultivated forms of *P. lunatus* which are obtained for human consumption from Madagascar, South America and Burma, and probably also those produced in the United States and Southern Europe, rarely, if ever, yield hydrocyanic acid in quantities likely to be injurious, but at the same time it is advisable that importations from new areas should be examined before being placed on the market.

United Kingdom Trade in "Haricot" Beans

The following table shows the quantities and values of beans, classed in the Trade Returns as "haricot" beans, imported into the United Kingdom during the period 1911–16; it includes all beans intended for human consumption, whether white or coloured.

Imports of "Haricot" Beans into United Kingdom

Quantity.		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	353,780	405,917	313,063	412,700	800,035	1,077,600
" value	£	257,627	311,738	238,685	313,763	751,017	1,239,325
From		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British India		75,560	88,660	67,900	176,730	504,595	726,800
Other British countries		13,960	10,040	8,160	5,305	35,050	74,670
Total, British countries		89,520	98,700	76,060	182,035	539,645	801,670
Russia		19,260	6,210	1,150	1,680	—	—
Germany		32,127	41,270	31,840	35,340	—	—
Netherlands		3,410	5,247	4,680	845	—	10
Belgium		23,000	34,300	21,942	11,450	—	—
France		6,589	28,545	32,901	34,604	2,400	3,350
Madagascar		67,620	85,620	71,820	78,850	131,670	138,570
Italy		13,564	2,290	5,270	7,830	190	—
Austria-Hungary		29,940	31,210	24,380	16,110	—	—
Rumania		48,620	34,460	8,580	4,560	—	—
Japan		6,350	15,215	1,100	70	97,020	51,170
United States		1,420	3,050	2,590	10,010	11,880	1,990
Peru		—	4,750	4,040	13,810	9,620	33,100
Chile		880	4,730	25,350	3,200	—	23,990
Other foreign countries		11,480	10,320	1,360	12,306	7,630	23,750
Total foreign countries		264,260	307,217	237,003	230,665	260,410	275,930

It will be seen from the above table that before the war the bulk of the imports of this class of pulse was derived from foreign countries; Madagascar, Germany, Austria-Hungary, Rumania and Belgium contributing the major portion. Since the outbreak of war, the imports from Madagascar, South America and Japan have largely increased, but the bulk of the imports have been derived from India.

The quantities and values of beans, classed in the Trade Returns as "haricots," re-exported from the United Kingdom and the principal receiving countries, are shown in the following table:

Re-exports of "Haricot" Beans from the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total re-exports	*cwts.*	37,979	92,822	119,736	127,284	94,440	74,852
" value	£	24,396	68,345	106,561	116,665	98,737	91,457
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Canada		973	23,604	17,883	14,620	108	14,634
Other British countries		6,990	9,439	10,177	6,180	10,918	12,322
Netherlands		2,951	2,447	14	4,229	840	—
France		3,151	5,298	827	8,949	43,308	27,976
United States		10,424	45,057	61,572	83,742	20	12,795
Cuba		368	—	26,473	4,400	1,960	—
Other foreign countries		13,122	6,977	2,790	5,164	37,286	6,925

From these figures it will be seen that in normal times the United States and Canada are the principal countries that receive the haricot beans re-exported from the United Kingdom, but since the outbreak of war larger quantities have been taken by France.

The exports of beans produced in the United Kingdom are not differentiated in the Trade Returns, but they are probably all horse beans (*Vicia Faba*). (See table, p. 525.)

Summary of United Kingdom Trade in "Haricot" Beans

	1911. *Cwts.*	1912. *Cwts.*	1913. *Cwts.*	1914. *Cwts.*	1915. *Cwts.*	1916. *Cwts.*
Total imports .	353,780	405,917	313,063	412,700	800,055	1,077,600
,, re-exports .	37,979	92,822	119,736	127,284	94,440	74,850
Net imports . .	315,801	313,095	193,327	285,416	706,615	1,002,750

Small-seeded Phaseolus

There are several species of Phaseolus that yield diminutive beans of great value as food-stuffs in the countries where they are grown, but which are little known in European commerce except as feeding-stuffs for cattle. These include the "adzuki" or "azuki" bean (*P. angularis*, W. F. Wight) of Japan and China; "mung" (*P. radiatus*, Linn.), "urd" (*P. Mungo*, Linn.), and "moth" (*P. aconitifolius*, Jacq.) of India; and the "rice" bean (*P. calcaratus*, Roxb.) of India and the Far East.

"Adzuki" Bean

In Japan and Chosen (Korea) large areas are cropped with the adzuki or azuki bean (*P. angularis*), and it is also grown to a less extent in Manchuria and China, but it does not appear to be grown on a large scale in India, although samples identical in appearance with this species have been received by the Imperial Institute under the name of *P. calcaratus* from the United Provinces, India. The plant is an annual, from 1 to 2½ ft. high, usually of bushy habit, but some varieties have branches that are slightly twining at the tips. In general appearance the plant resembles that of

the kidney bean (*P. vulgaris*); the leaves are trifoliate and hairy, and the flowers are bright yellow. The pods are thin and slender, from $2\frac{1}{2}$ to 5 in. in length, each containing from 8 to 10 seeds. There are numerous varieties that differ from each other mainly in the time required to attain maturity and in the colour of the ripe pods and seeds. In colour the seeds vary from straw-yellow to grey; grey speckled with black; red to brown, black and blue-black. The most common form is the red-seeded variety. In all cases the hilum (eye) is white and is placed towards the lower end of the seed. The seeds, which are about the size of small peas, are slightly longer than broad, nearly cylindrical, being only slightly compressed on the sides, with blunt (truncate) ends.

Adzuki beans are used on a large scale as human food in Japan usually in the form of a meal or paste. Owing to their texture, these beans are easily ground into flour or formed into a paste by being treated in either the dry or soaked condition. In both cases the husks are separated by passing the ground product through sieves, the paste form being afterwards dried for use. The bean meal obtained by grinding is not only used as a pulse, but is also made into sweet-meats of various kinds. The whole beans are also "popped" like maize, and are sometimes candied. The absence of a beany flavour enables this bean to be utilised in many ways that would not be possible in the case of varieties possessing the characteristic taste of beans.

Introduced into the United States, the adzuki bean has been grown on an experimental scale with favourable results. At the Arlington Farm, Virginia, some sixty distinct varieties of this species have been tested, the yields obtained varying from 12·0 to 28·6 bushels per acre in 1912 (*Bulletin No.* 119, 1914, *Bur. of Plant Indust.*, *U.S. Dept. Agric.*).

During the year 1916 adzuki beans have been received on the London market and samples have been received by the Imperial Institute in collections representing beans imported for human consumption. The large demand for these beans is said to be due to the need of a substitute for the peas and beans usually imported. In view of

the high yield of seed which is obtained from the plant and the value of the beans as a food-stuff for human consumption, the cultivation of this variety in suitable localities within the Empire appears to be desirable. The soil and climatic conditions favourable to the growth of French or kidney beans are said to suit its requirements, so that in localities where these beans succeed the cultivation of the adzuki bean might be attempted with possibilities of success.

"Mung," "Urd," and "Moth" Beans

The seeds of the three closely allied species—"mung" (*Phaseolus radiatus*, Linn.), "urd" (*P. Mungo*, Linn.) and "moth" (*P. aconitifolius*, Jacq.)—are largely grown in India for human consumption. The nomenclature of the first two of these species is somewhat confused, the botanical names being frequently reversed. The mung bean is commonly spoken of as green gram owing to the fact that the form usually met with produces green or yellowish-green seeds, whilst the term black gram is used for urd, which commonly produces black seeds, although both species include varieties that yield seeds of various colours.

The mung bean is grown throughout India, but almost invariably as a subordinate crop. The plant is erect or sub-erect and much branched, with stems from 1 to 4 ft. in length, more or less twining at the tips, and furnished with trifoliate leaves resembling those of the dwarf French bean. The flowers are pale yellow, and are produced in crowded clusters of from 10 to 25 flowers. The pods are cylindrical, and contain from 6 to 15 seeds per pod; the seeds are small, almost round, being but slightly longer than broad, with a small but prominent white hilum (eye) placed in the middle. In colour the seeds vary from dull green (var. *typica*) to yellow, dark brown or black, and in the case of the last three varieties the testa, or seed coat, is covered with wavy striations, plainly seen under slight magnification.

The urd bean plant is similar in appearance to mung, but the pods are shorter and are produced in less dense clusters, usually in twos or threes at the ends of the

peduncles and radiating horizontally. The seeds are slightly longer than those of mung, and vary in colour from dull green to brown and black.

The moth bean plant is readily distinguished from the other small-seeded species by its slender, trailing, hairy stems furnished with trifoliate leaves, the leaflets of which are cut into slender lobes so that they resemble the leaves of aconites (*Aconitum*). The pods, 1 in. to $1\frac{1}{3}$ in. in length, are produced in clusters of 3 to 4 pods at the ends of slender peduncles, and contain from 4 to 8 seeds each; the seeds are small, longer than broad, straw-coloured to greenish-brown, occasionally speckled with black. In India the moth bean is cultivated chiefly in the United Provinces and Assam, often on poor land that can be made to produce no other crop. It is frequently grown associated with bajra, the bulrush millet. When grown alone, it receives but little cultivation, yet it gives a larger yield of seed than mung or urd, namely about 560 lb. per acre. The beans are eaten by the poorer classes, but are considered inferior to mung and urd, their chief use being as a cattle food.

"*Rice*" *Bean*

The rice-bean (*P. calcaratus*, Roxb.) is found wild in India, and also cultivated throughout the tropical zone from the Himalayas to Ceylon and to a limited extent in Japan, China, Mauritius, Java and the Philippines. It may be grown at a higher elevation than most other pulses, being found at an altitude of 6,500 ft. in the N.W. Province and of 5,000 ft. in the Khasia Hills.

The plant is an erect or sub-erect annual, from 1 ft. to 2 ft. 6 in. high, with twining branches several feet in length furnished with trifoliate leaves resembling those of the dwarf French bean. The young vegetative parts are clothed with short, fine white hairs that are deciduous. The flowers are yellow, produced in short racemes composed of from 5 to 20 flowers; the pods are slender, nearly cylindrical, 3 to 4 in. long, curved, with a pointed tip, and each pod contains from 8 to 12 seeds. According to the variety and state of maturity the seeds vary in colour from straw-yellow to greenish-yellow, brown,

maroon or black. The prominent white hilum (eye) raised above the surface and crinkled at the margin, readily distinguishes this species from the other small-seeded kinds. Several distinct forms occur in a wild state, and these have received the following varietal names: *P. c. major*, Prain, a large-flowered variety native to India and Burma; *P. c. glaber*, Prain, a glabrous plant originally from Mauritius, but also found in northern India; *P. c. rumbaiya*, Prain, a form having short, erect or spreading stems, native to the Khasi hills of Assam; *P. c. gracilis*, Prain, with slender stems and narrow leaflets.

Although grown to a considerable extent in eastern countries, the beans produced by this species are not so valuable as adzuki beans. In Burma it is cultivated at all elevations, chiefly as a cold-weather crop. It is largely grown on the silt of islands and on river-banks, but is also cultivated away from rivers.

The beans are largely consumed by the natives in Burma in combination with, or instead of, rice. In districts where there is a surplus, the beans are bought up by brokers and sent to Rangoon for distribution to consuming areas. These beans are sometimes known locally in Burma as "Lobia," a name applied also to the seeds of *Vigna Catjang*, the cow pea (see p. 534).

There is no doubt an import of the small beans above mentioned into the United Kingdom, but it is not possible to state to what extent they are imported, as they are not separately detailed in the Trade Returns, but presumably they are included in the table shown on p. 541 amongst gram or with peas.

Broad, Field or Horse Beans

The common broad bean, or "Windsor" bean, is the seed of *Vicia Faba*, Linn. (syn. *Faba vulgaris*, Moench.), an annual plant 2 to 4 ft. high, with erect 4-angled stems furnished with glaucous green leaves composed of from 3 to 7 leaflets that are ovate-elliptic in shape with entire margins. The flowers are produced in short racemes of from 2 to 6 flowers in the axils of the leaves; they are pure white, with a black patch in the centre of each of

the wing petals. The pods are either broad and flattened, containing 3 to 5 seeds, or long and more or less cylindrical in shape, with a variable number of seeds in each.

The broad, or "Windsor" bean is commonly grown as a garden crop for the sake of its young seeds, which are eaten as a green vegetable. Several forms of this species, with longer pods and smaller seeds, are grown as field crops, the seeds being known in commerce under the general term horse beans.

Varieties and Production of Vicia Faba Beans

The principal varieties in cultivation are the following:

(1) The Heligoland bean.—A small roundish seed of a chocolate colour; 1,000 seeds weigh about 12 oz.

(2) The English horse bean or tick bean.—Oval plump seeds of a brown colour; 1,000 seeds weigh about 18 oz.

(3) The Scotch horse bean.—Seeds similar to the preceding, but larger and flatter; 1,000 seeds weigh about 27 oz.

(4) Winter field bean.—Small oval seeds of a greyish-green colour with a jet black hilum or "eye"; 1,000 seeds weigh about 12 to 13 oz.

(5) Early Mazagan bean.—Flat whitish beans larger than any of the preceding; 1,000 seeds weigh about 30 oz.

(6) Long-pod bean.—Flat seeds with a roundish outline produced in pendulous flattened pods; 1,000 seeds weigh about 55 oz.

(7) Broad, or "Windsor" bean.—Large flattened seeds with an irregular rounded outline and grey-green colour; 1,000 seeds weigh from 100 to 110 oz. There are numerous nurserymen's varieties that differ chiefly in habit of growth or period of ripening.

The field bean is a common crop in Europe, and is largely grown for export in Egypt, Turkey and China.

In the United Kingdom the eastern counties are the most important producing area, and there is also a considerable acreage under this crop in Scotland. According to the British Agricultural returns, the area under this

crop in the United Kingdom in 1914, an average year, was 291,730 acres, and the yield 1,120,078 quarters. Since the war the area devoted to beans has been reduced, amounting to 242,695 acres in 1916, when the yield was 892,572 quarters; in 1917 the yield was only about half that of 1916.

Cultivation of Field or Horse Beans

The field bean succeeds best on a stiff clay or heavy loam soil, and is frequently grown as a rotation crop with wheat as an alternative to clover. With the exception of the winter field bean, which, as its name implies, can withstand the winter cold in this country, beans are usually sown in the spring. The winter variety is sown in October, or as soon as the land can be ploughed after a cereal crop has been harvested. The methods of cultivation vary in different localities, but the usual practice is to plough the land in the autumn, and in spring to throw it into ridges. Farmyard manure is then spread in the hollow of the ridges at the rate of from 8 to 10 tons per acre, and the seed is sown by hand dibbling in the dung. After sowing, the ridges are split, by which operation both manure and seeds are covered with soil. Later on the ridges are broken down by harrowing so as to facilitate the emergence of the seedlings, and as soon as the young plants appear above the ground the soil is cultivated by hand-hoeing or horse-hoeing. Machine drilling in rows from 20 to 22 in. apart is now generally practised, the soil being brought to a fine tilth before drilling takes place.

In Scotland beans are frequently broad casted and grown as a mixed crop with oats.

Field beans are ready for harvesting as soon as the leaflets have fallen from the leaf-stalk and the lower pods begin to blacken. The method of harvesting formerly in vogue was to pull up the plants by hand or cut them with a sickle, but the modern self-binder can now be employed for reaping this crop. The pods are liable to open, with consequent loss of seed, if the crop is handled during bright weather; it is therefore advisable to choose a dull day or an early hour before the dew has disappeared for harvesting this crop.

Field beans are a well-known and valued food-stuff

for animals, and are especially valued for horses on hard work. They are used either whole, split or ground into meal. In the latter form they are commonly fed to cows in full milk.

United Kingdom Trade in Broad, Field or Horse Beans

Large quantities of these beans are imported into the United Kingdom for consumption in addition to those produced locally. The Trade Returns of the United Kingdom do not separately mention this class of bean, but they are included in the following table of "Beans, other than haricots," imported into the United Kingdom.

Imports of Beans, classed in the Trade Returns as "Beans (not fresh) other than Haricot Beans," into the United Kingdom during the period 1911–16

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity, *cwts.*	1,029,101	1,256,741	1,540,405	1,441,559	1,142,810	1,110,605
" value . £	375,333	470,847	568,189	502,928	534,139	687,119
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Egypt . .	30,550	69,280	2,220	1,140	377,660	333,460
British India .	168,730	72,880	43,121	32,650	190,270	126,410
New Zealand .	6,480	9,120	15,880	4,650	2,700	1,570
Other British countries . . .	2,417	7,196	5,690	12,137	3,190	7,260
Total British countries . .	208,177	158,476	66,911	50,577	573,820	468,700
Russia [1] . .	1,810	740	67,635	8,890	—	—
Germany . .	14,050	19,270	49,450	19,750	—	—
Netherlands . .	21,994	1,810	10,180	12,580	1,810	370
Italy . . .	5,030	1,570	6,880	290	1,720	1,420
Austria-Hungary .	1,660	14,490	3,670	130	—	—
Turkey . .	199,440	32,080	11,960	28,960	—	—
Morocco . .	161,390	54,480	—	900	53,640	17,920
China [1] . .	406,520	903,830	1,291,980	1,254,684	459,370	591,800
Other foreign countries	9,030	68,995	31,739	64,798	52,450	30,395
Total foreign countries	820,924	1,098,265	1,473,494	1,390,982	568,990	641,905

[1] *Exclusive of soy beans which are returned separately.*

It will be seen from the above table that before the outbreak of war China, Germany and Turkey supplied a large proportion of the imports. In 1915, however, more than half the total import was obtained from British countries, British India and Egypt having largely increased their usual contributions.

The following tables show the quantities of beans

other than haricot beans exported and re-exported from the United Kingdom.

Exports of Beans (not Fresh), other than Haricot Beans, from the United Kingdom (Produce of the United Kingdom)

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	283,056	242,008	287,664	178,635	4,663	3,893
,, value	£	108,668	103,856	117,572	68,783	4,595	4,973
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British countries		1,219	1,075	737	997	1,862	1,462
Belgium		206,620	154,010	204,160	155,548	—	—
France		45,254	55,845	79,415	19,765	267	387
Netherlands		24,135	25,141	552	901	561	234
Other foreign countries		5,828	5,937	2,800	1,424	1,973	1,810

Re-export of Beans (not Fresh), other than Haricot Beans, from the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	72,374	83,061	71,153	176,787	100,567	6,354
,, value	£	49,451	61,495	34,018	66,987	42,885	6,881
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Canada		3,379	11,363	2,926	827	50	2,066
Australia		2,207	2,441	242	21	—	—
Other British countries		1,873	3,478	3,737	4,752	838	1,900
United States		30,978	40,175	11,424	—	—	2,039
Belgium		6,714	1,447	819	—	—	—
Portugal		2	3,276	2,565	15,131	400	—
Italy		19	2	64	21,039	—	—
Cuba		600	1,990	480	—	—	—
Germany		20,402	811	1,465	459	—	—
Netherlands		2,787	5,790	8,596	84,626	86,311	—
Canary Islands		1,679	7,955	31,873	43,464	9,592	—
Other foreign countries		1,734	4,333	6,962	6,468	3,376	349

Summary

	1911.	1912.	1913.	1914.	1915.	1916.
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Imports	1,029,101	1,256,741	1,540,405	1,441,559	1,142,810	1,110,605
Exports	283,056	242,008	287,664	178,635	4,663	3,893
Re-exports	72,374	83,061	71,153	176,787	100,567	6,354

World's Production of Beans

The following table, taken mainly from the Agricultural Statistics (Foreign and Colonial) for 1912, issued by the Board of Agriculture and Fisheries in 1912, indicates the importance of the bean crop, including haricots, broad beans and other kinds, in some of the chief producing countries of the world:

	Area. 1910. Acres.	1911. Acres.	1912. Acres.	Production. 1910. Quarters.	1911. Quarters.	1912. Quarters.
United Kingdom	271,881	313,516	287,410	1,093,365	967,692	973,006
Australia [1] .	42,239	49,237	40,382	116,483	101,313	105,954
Burma [2] . .	215,000	223,000	241,000	79,489	66,422	72,955
Canada . .	53,034	60,630	59,800	147,225	144,450	130,100
Egypt . .	563,061	538,532	—	—	—	—
New Zealand .	1,798	—	—	9,019	—	—
Algeria . .	88,312	92,272	—	536,078	528,675	—
Argentina .	64,220 [3]	65,764	—	—	—	—
Austria [4]. .	625,592	625,730	636,494	5,176,820	4,746,771	4,907,515
Belgium . .	22,830 [3]	21,237	20,098	78,542 [3]	82,693	64,177
Bulgaria [5] .	139,190	180,123	—	211,239	252,600	—
Chile . .	89,355	72,196	90,301	201,225	170,013	208,582
Denmark [4] .	—	—	—	66,997	63,211	66,778
France [5] . .	621,946	650,845	631,258	1,377,027	1,165,186	1,376,595
Germany .	1,511,242 [6]	—	—	—	—	—
Hungary. .	2,021,483	2,029,802	—	933,199	1,216,949	—
Italy . .	1,503,835	1,509,343	1,475,825	2,340,602	2,373,157	1,846,768
Japan [7] . .	345,634	345,683	—	598,794	592,533	—
Luxemburg .	4,281	3,285	2,791	11,232	6,347	6,553
Mexico . .	—	—	—	65,022 [8]	62,157 [8]	177,902 [8]
Netherlands .	65,571	63,289	—	218,509	201,609	—
Rumania [9] .	99,568	126,543	149,326	157,167	200,657	219,903
Russia in Europe	167,883	157,337	165,961	293,542	324,885	345,615
,, ,, Asia	22,842	26,365	27,089	32,362	36,810	46,897
,, (Finland) [1]	—	—	—	26,963	—	—
Serbia . .	21,526 [10]	24,000 [11]	30,000 [11]	137,092 [10]	181,625 [11]	186,375 [11]
Spain . .	1,094,190	1,113,735	1,119,510	1,504,190	1,628,962	1,316,434
Sweden . .	10,110	9,566	—	26,170	18,630	21,072
United States [11]	784,000 [3]	—	—	1,393,000 [3]	—	—

[1] *Including peas.*

[2] *Red and white Phaseolus lunatus beans; the figures in the* 1910 *columns are the normal matured area and production.*

[3] *Previous year's figures.* [4] *Including other pulses.*

[5] *Including peas, haricots and lentils.*

[6] *Census figures for* 1900, *including peas and vetches.*

[7] *Adzuki beans only.*

[8] *For years* 1905, 1906 *and* 1907 *respectively.*

[9] *Beans, peas, haricots and lentils. In addition,* 362,572 *quarters of haricots were produced with the maize crop in* 1910, 429,251 *quarters in* 1911, *and* 427,414 *quarters in* 1912. [10] *Figures for* 1908.

[11] *Figures taken from the Yearbook of the United States Department of Agriculture,* 1914.

PEAS

Peas form a well-known class of pulse, largely produced in the temperate countries of the world, particularly in Russia and Canada.

The following table, taken from *Agricultural Statistics* (Foreign and Colonial) for 1912, issued by the Board of Agriculture and Fisheries, indicates the area and production of peas in the chief countries concerned with this crop:

	Area.			Production.		
	1910.	1911.	1912.	1910.	1911.	1912.
	Acres.	*Acres.*	*Acres.*	*Quarters.*	*Quarters.*	*Quarters.*
United Kingdom	168,958	168,204	202,598	501,451	463,197	499,562
Canada . .	386,100	288,310	250,820	817,262	567,012	471,687
New Zealand .	14,829	19,946	—	63,950	80,731	—
Algeria . . .	22,571	25,394	—	36,691	39,163	—
Belgium . .	12,338 [1]	12,293	12,301	35,061 [1]	52,138	51,105
Chile . .	5,444	4,404	4,572	5,540	4,124	4,745
Hungary . .	29,936	29,188	—	51,914	51,830	—
Luxemburg .	2,149	1,855	1,677	4,299	3,814	3,025
Mexico [2] . .	—	—	—	186,712 [3]	318,519 [3]	230,542 [3]
Netherlands . .	64,568	55,234	—	152,668	222,691	—
Russia in Europe	2,504,771	2,468,699	2,511,915	3,502,455	3,208,200	4,003,492
,, Asia .	78,829	88,892	84,991	94,020	86,408	85,537
Spain [2] . .	511,722	539,761	521,368	529,639	531,914	445,325
Sweden . .	43,037	43,801	—	144,692	127,222	—
United States	1,302,000 [4]	—	—	888,750 [4]	—	—

Figures for the following countries are included under beans in the table on p. 526, Australia, Bulgaria, France, Germany, Rumania, Russia (Finland).

[1] *Previous year's figures.* [2] *Mainly chick peas.*

[3] *Figures for years* 1905, 1906 *and* 1907 *respectively.*

[4] *Census figures for* 1909, *from the Yearbook of the United States Department of Agriculture,* 1914.

Two species are recognised as being the sources of the many cultivated forms of peas; these are *Pisum arvense*, Linn., the grey, or field pea, and *P. sativum*, Linn., the garden pea. The grey, or field pea is a dwarf plant with tendrilled leaves composed of 2 to 6 ovate entire leaflets, and possessing leafy, persistent stipules. The flowers are either solitary or in racemes of from 2 to 3 flowers; they are usually purple in colour, but some forms are pinkish-white. The pods contain from 4 to 8 rounded smooth or wrinkled seeds varying in colour, according to the particular variety, from yellowish or greyish-green to deep purplish-brown, sometimes marbled or speckled. The chief varieties of field pea cultivated are Common Grey, Warwick Grey, Hastings Grey, Partridge pea, Maple pea and Dun pea. All the varieties are yellow-fleshed, and are therefore suitable for making pea-flour or for split peas after being husked. The husks removed from split peas are utilised in the manufacture of compound cattle foods.

The garden pea differs from the field pea in having white flowers and a less hardy constitution. Many of the varieties have tall stems, and others, known as "sugar" peas, have no membraneous lining to the pods, so that the latter can be used as a green vegetable (*pois mange*

tout). The seeds may be either green or yellow and smooth or wrinkled. Numerous varieties are in cultivation, and their number is constantly being added to by seedsmen. They are largely grown as garden crops on account of the young green peas, which form an important vegetable, but certain varieties are grown as field crops for the production of dried peas. For the last-named purpose green-seeded kinds are chiefly grown. These are hand-picked, and, after being carefully dried, are put up into small packages for domestic purposes. After being soaked in water and cooked in the ordinary way they serve as a substitute for fresh green peas. Large quantities are also preserved by heat-sterilising processes (tinned peas). To supplement the home-grown supplies of dried green peas, large quantities have in recent years been imported from Japan and smaller quantities from Chile. The imports from New Zealand consist largely of garden varieties which are used for sowing in this country.

Cultivation of Peas

Peas differ from field beans in requiring a light calcareous soil, and they are therefore grown as an alternative leguminous crop to beans where a heavy soil is not available. Good crops may sometimes be procured from a gravelly or sandy soil provided lime is present and the season is favourable.

The cultivation of peas does not present any difficulties if suitable land is available. The land should be clean and in a good state of cultivation. It is usually prepared just before sowing, which in this country takes place in February or March. The seed is sown at the rate of about 3 bushels per acre in rows about 1 ft. apart. After the seedlings appear above ground, the land is kept well worked either by hand-hoeing or by horse-hoeing until the stems of the plants sufficiently cover the ground to choke weeds, and prevent excessive drying. Harvesting usually takes place in from 6 to 8 weeks after the flowering period, or as soon as the pods begin to change in colour from green to brown. The cutting is usually done by hand by means of a pea-hook, the stems being left in rough heaps or bundles on

the ground to dry for a few days before stacking. As the pods readily burst, it is advisable to handle the crop on a dull day, otherwise loss of seed is liable to occur. Peas do not keep well stacked, and early thrashing is therefore usually carried out.

United Kingdom Trade in Peas

The following tables show the trade in peas in the United Kingdom during recent years:

Imports of Peas, other than Split Peas, into the United Kingdom

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity *cwts.*	2,084,174	2,464,607	1,882,433	924,441	1,064,213	981,331
,, value . £	948,773	1,226,114	947,296	508,454	840,259	1,279,112
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British India . .	1,320,290	1,483,900	962,350	183,410	469,860	307,970
New Zealand . .	164,390	203,290	185,993	137,156	77,447	25,564
Australia . .	48,500	16,770	5,620	30,900	11,700	7,330
Canada . . .	21,010	7,050	5,770	7,340	10,480	12,530
Other British countries . . .	3,120	1,500	1,970	300	1,700	220
Total British countries . . .	1,557,310	1,712,510	1,161,703	359,106	571,187	353,614
Russia . . .	95,510	63,840	155,120	170,580	—	—
Germany . .	146,760	246,582	222,270	118,942	—	—
Netherlands . .	170,470	227,264	179,520	73,570	910	1,485
Belgium . .	4,764	7,650	1,480	770	—	—
China	—	14,260	150	24,790	59,320	84,160
Japan . . .	88,810	120,250	149,200	153,190	409,640	458,210
United States . .	8,190	14,350	3,560	5,190	18,836	79,910
Chile . . .	6,020	—	760	500	720	3,000
Other foreign countries	10,340	57,901	8,670	17,803	3,600	952
Total, foreign countries	526,864	752,097	720,730	565,335	493,026	627,717

Exports of Peas (not fresh), other than Split Peas, from the United Kingdom (Produce of the United Kingdom)

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity *cwts.*	108,240	41,471	53,926	35,994	40,991	23,242
,, value . £	113,244	57,645	58,356	38,900	57,369	48,017
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Canada	3,153	6,509	9,169	2,496	674	454
Other British countries	2,940	3,438	6,208	7,028	4,572	2,401
France	34,514	14,758	16,808	11,155	15,902	11,316
Belgium . . .	3,362	2,893	7,689	2,063	—	—
United States . .	4,332	1,428	5,303	4,048	1,444	316
Germany . . .	3,201	1,826	1,339	607	—	—
Denmark . . .	5,584	5,425	3,851	3,647	11,744	5,129
Netherlands . .	48,866	3,389	942	2,933	3,065	256
Other foreign countries	2,288	1,805	2,527	2,017	3,590	3,370

Re-exports of Peas (not Fresh), other than Split Peas, from the United Kingdom

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity *cwts.*	40,958	104,483	37,465	31,567	25,087	24,471
,, value . £	31,992	93,178	31,831	25,158	27,841	47,431
To	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Canada	213	5,431	7,467	3,234	—	18
Other British countries	4,212	6,530	8,446	6,486	2,939	2,225
France	6,749	7,823	7,786	7,027	12,417	18,625
Italy	—	—	—	1,580	—	—
United States . . .	7,508	5,171	8,869	1,216	404	332
Norway	—	5	4	2,050	1,543	2,604
Netherlands . . .	19,916	11,490	2,755	4,888	6,914	—
Switzerland . . .	—	10	—	4,430	6	10
Spain	71	41,378	2	167	440	—
Other foreign countries	2,289	26,645	2,136	489	424	657

Summary of Trade in Peas

	1911.	1912.	1913.	1914.	1915.	1916.
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Imports .	2,084,174	2,464,607	1,882,433	924,441	1,064,213	981,331
Exports .	108,240	41,471	53,926	35,994	40,991	23,242
Re-exports .	40,958	104,483	37,465	31,567	25,087	24,471

It will be seen from these tables that in normal times the principal British countries that supply this country with peas are India, and New Zealand, and the principal foreign countries are Germany, Holland and Japan. Since the outbreak of war Japan and China have largely increased their contributions.

The quantities exported and re-exported vary considerably in different years, France being the largest purchaser of peas produced in the United Kingdom, and Holland the principal country to receive the re-export of foreign and colonial peas.

The United Kingdom trade in split peas during recent years is shown in the following tables:

Imports of Split Peas into the United Kingdom

	1911.	1912.	1913.	1914.	1915.	1916.
Total quantity *cwts.*	111,920	110,100	95,882	59,253	35,740	10,390
,, value . £	64,089	65,488	59,439	38,016	32,148	11,493
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Germany . . .	104,270	106,080	91,710	53,083	—	—
Other foreign countries	6,690	4,020	2,602	3,460	2,400	2,360
British countries .	960	—	1,570	2,710	33,340	8,030

Exports of Split Peas, from the United Kingdom (Produce of the United Kingdom)

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	11,139	48,623	53,338	34,730	42,768	29,518
,, value	£	6,234	26,412	31,484	24,049	49,515	36,736
To		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British countries		6,402	35,977	40,177	25,406	8,694	6,264
Foreign countries		4,737	12,646	13,161	9,324	34,074	23,254

Re-exports of Split Peas from the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	3,691	10,308	19,060	2,245	3,673	7,765
,, value	£	2,083	6,164	11,166	1,740	4,413	9,059
		Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Canada		11	3,033	8,010	184	5	—
Other British countries		3,331	6,776	9,290	1,407	1,229	1,468
Foreign countries		349	499	1,760	654	2,439	6,297

Summary of Trade in Split Peas

	1911.	1912.	1913.	1914.	1915.	1916.
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
Imports	111,920	110,100	95,882	59,253	35,740	10,390
Exports	11,139	48,623	53,338	34,730	42,768	29,518
Re-exports	3,691	10,308	19,060	2,245	3,673	7,765

It will be seen that prior to the outbreak of war, split peas were obtained chiefly from Germany, and the bulk of this import was retained for home consumption. For the two years, 1915 and 1916, the total export, including the re-exports, of split peas from the United Kingdom have exceeded the imports by 10,701 cwts., and 26,893 cwts. respectively.

Mutter Peas

Mutter peas, known locally in India as khesari, are the seeds of the chickling vetch or vetchling (*Lathyrus sativus*, Linn.), an annual herb extensively cultivated in Southern Europe and eastwards as far as India. The plant is a slender, much-branched herb with winged stems furnished with pinnate leaves consisting of

one or two pairs of lance-shaped leaflets and a simple or branched tendril. The flowers, borne singly on long stalks in the axils of the leaves, are pea-shaped, of a bright blue or purplish colour in the Indian forms and white in the Mediterranean varieties. The pods are oblong in shape, with a narrow wing along the opening; each pod contains from 3 to 5 seeds, which are more or less wedge-shaped, of a grey colour speckled with brown or black, or, in the case of the white-flowered Mediterranean forms, pale green or buff yellow, with a very hard yellow interior. In general appearance the speckled seeds from India resemble the grey, or field pea, from which they may be readily distinguished by being wedge-shaped and slightly smaller. About 488 seeds weigh 1 oz.

The mutter pea is cultivated throughout India as a cold-weather crop, and is of great value agriculturally, as the seed is said to be capable of germinating on land that is too dry for other rabi crops. It is of greatest importance as a crop in the Central Provinces; considerable areas are also under this crop in Sind, Bombay and the United Provinces. It is said to thrive best on deep retentive black soils, and is generally raised on low-lying fields liable to be flooded during heavy rains, and unsuited to other pulse crops. It is usually sown broadcast in October and November and reaped in March and April.

From Mediterranean countries the white-flowered form has been introduced to Canada, where it is known as the "grass" pea, and is produced on a fairly large scale in Ontario.

Although these peas contain a high percentage of protein and are therefore a valuable food-stuff, certain forms are reputed to have poisonous properties which produce the disease known as lathyrism, a paralysis of the lower extremities in man and animals, as a result of their continued use for food. In Mauritius they are considered dangerous to human beings and nearly all animals, but are said to be extensively used as a food for milch cows. In India they are eaten by the poorer classes on account of their abundance and cheapness.

The nature of the toxic substance causing lathyrism is not known. Seeds of several forms of *Lathyrus sativus* obtained from India, Cyprus and Canada have been examined at various times at the Imperial Institute with a view to the isolation of a toxic constituent, but the results have been of a negative character. Recently similar investigations have been conducted at the Agricultural Research Institute at Pusa on samples obtained from Barail, a village near Pusa, which is notorious for cases of lathyrism, and from the Central Provinces, where cases of the disease are also known to occur, but no alkaloids were detected. During the course of this work at Pusa, it was noticed that the samples of khesari were often contaminated with the seeds of *Vicia sativa* (*akta*) and *Vicia hirsuta* (*misia*), from which a cyanogenetic glucoside was isolated (*Rep., Agric. Res. Inst. and Coll. Pusa*, 1915–16, pp. 19–20). It is possible, therefore, that the harmful properties attributed to the seeds of *Lathyrus sativus* may in some cases be due to obnoxious impurities. Experiments conducted in Canada with Canadian grown *Lathyrus sativus* peas as food for fowls gave good results, and no harmful effects from their use as poultry food were observed (*Rep., Dominion Exper. Farm, Canada*, 1901, pp. 183–5).

In the course of an extensive enquiry into the causation of lathyrism, conducted in India in 1903 by Major A. Buchanan, I.M.S., it seemed to be clearly established that the disease only occurs in human beings when *Lathyrus sativus* peas form almost the sole diet, and that where they are used only as a small part of the diet no harmful effects ensue. There is now a good deal of evidence in favour of the view that the use of any one kind of grain, even wheat, as the sole diet may lead to harmful results.

In spite of the suspicion with which the peas are regarded, they appear to be still occasionally imported into Europe for use as a feeding-stuff for animals. The extent of this trade cannot be ascertained. Probably the peas are always used in small quantities mixed with other feeding-stuffs, and as they are commonly cooked before adding them to mixed feeding-stuffs, any deleterious effects may thereby be avoided.

Cow Peas

The cow pea, *Vigna Catjang*, Walp., is an annual, sub-erect bushy or trailing plant more closely allied to the beans (*Phaseolus*) than to the true peas (*Pisum*). There are many cultivated forms of the species belonging both to the bushy (var. *typica*) and trailing (var. *sinensis*) types, and these differ among themselves not only in habit of growth, but also in the length of pod and in the size, shape and colour of their seeds. The plants are furnished with trifoliate leaves resembling those of the French bean; the flowers are borne in small crowded clusters, and are succeeded by long, narrow pods that may attain a length of from a few inches to as much as 18 in. The pods contain a variable number of seeds that may be pure white, red, brown or black in colour, sometimes white with a purple or black blotch round the hilum ("black-eyed" or "purple-eyed" peas) or variously mottled or speckled ("whip-poor-wills").

The cow pea is grown in most warm countries of the world either as a garden or a field crop, and is much valued as a fodder and green manure, particularly in the Southern States of America. The immature pods are eaten in countries where they are produced as a vegetable, and the dried seeds of some of the varieties are utilised as a pulse. For the latter purpose the white or blotched forms are preferred.

The cultivation of cow peas presents no difficulties; the seeds are sown either broad-cast or drilled in rows from 2 to 3 ft. apart at the commencement of the rainy season in tropical countries or as soon as the soil has become warm and mellow in sub-tropical areas. The soil between the plants is kept cultivated by hoeing until the plants cover the ground, little further attention being afterwards required until the seeds have fully developed, when the pods are ready for harvesting. In India cow peas are frequently grown as a mixed crop with maize or sesamum or with other kinds of peas or beans. In Burma the dried seeds are parched or boiled and eaten like peas, and they are also used as a substitute for nuts for making sweetmeats. On account of their distinctive and agreeable flavour, the dried seeds are also appreciated in the United States. Small quantities of the "black-eye" variety are imported into the United King-

dom for human consumption, but the extent of the trade cannot be ascertained, as this pulse is not separately recorded in the Trade Returns. Should the demand for cow peas increase, it would be possible to rapidly extend the cultivation of this crop in such countries as Burma, where it is already cultivated on a considerable scale.

Lentils

Lentils are a well-known and highly valued pulse, largely consumed as human food in European countries as well as in the East. The plant which produces lentils is known botanically as *Lens esculenta*, Moench. (syn. *Ervum Lens*, Linn.). It is a slender, branched annual, from 6 in. to 18 in. high, with pinnate leaves usually composed of from 4 to 6 pairs of oblong leaflets, terminated by a tendril. The whitish or pale blue flowers are usually borne in pairs on slender peduncles in the axils of the leaves. The pods, which succeed the flowers, are short and broad, and each contains two flattened seeds which have the form of a bi-convex lens. There are several forms of the plant in cultivation, and these differ from each other in size, hairiness and colour of the vegetative parts, and more particularly in the size and colour of the seeds. The last may vary in colour from yellow or grey to dark brown, sometimes speckled or mottled.

The native country of *Lens esculenta* is not known, but in cultivation it is met with in India, Persia, Syria, Egypt and North Africa, and in Europe along the Mediterranean Coast and as far north as Russia, Germany, Holland and France.

Cultivation and Varieties

The lentil prefers a light, low-lying moist soil, but in situations where droughts are liable to occur it succeeds best on heavier soils that are retentive of moisture. On rich soils the plants are liable to produce much leaf but few pods and seeds.

In Europe the crop is sown in spring after frosts are over, in drills 1 to 1½ ft. apart, and harvesting takes

place usually about August or September, or as soon as the plants begin to turn yellow. The usual method of harvesting is to pull up the plants by the roots, as in the case of flax, and after drying to stack until the seeds are required. The yield in Europe is about 11 cwts. of seed and 30 cwts. of straw per acre.

In India, lentils are grown as a winter crop, especially in the Central Provinces, Madras and the United Provinces. The crop usually follows rice, and may be grown with or without irrigation, but with irrigation a larger return is usually obtained. The rate of sowing is usually about 1 maund (82 lb.) per acre, and the outturn ranges from 6½ to 8 maunds of seed, or, with irrigation, from 10 to 12 maunds. The lentil grows in many parts of Burma, but at present the crop is of little importance there. With a good market and remunerative prices for the produce it would seem that there are possibilities of considerably extending the cultivation.

In English commerce two kinds of lentils are chiefly met with known as the "French" and "Egyptian." The former are large, of an ash-grey colour externally, yellow inside, and are usually sold entire; they are obtained chiefly from Russia and Germany. The "Egyptian" lentils are small and brown, with an orange-coloured interior, and are usually marketed in the "split" form; they come chiefly from India.

United Kingdom Trade in Lentils

The imports of lentils into the United Kingdom for the period 1911 to 1916 are shown in the following table:

Imports of Lentils into the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	*cwts.*	262,370	199,912	224,020	237,180	329,870	143,960
,, value .	£	83,089	72,046	76,926	90,607	249,840	135,466
From		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
India . . .		241,830	9,050	150,250	158,290	319,230	120,140
Russia . . .		12,240	1,900	11,390	14,540	—	—
Germany . .		5,580	8,820	62,230	64,140	—	—
Other countries .		2,720	142	150	200	5,080	23,820

The greater part of the import is retained in the United Kingdom, as is indicated by the following table :

Re-exports of Lentils from the United Kingdom

		1911.	1912.	1913	1914.	1915.	1916.
Total quantity	cwts.	2,455	3,462	6,522	5,342	15,233	3,583
,, value	£	1,487	2,617	4,164	5,260	18,230	5,278
To		Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
France		20	1		3,455	13,548	803
Other foreign countries		873	1,226	3,475	262	55	598

Dhol, or Pigeon Pea ; Gram, or Chick Pea

In the Trade Returns of the United Kingdom these two pulses are grouped together, the quantities of each kind imported not being shown separately.

Pigeon Pea

The plant whose seeds constitute the dhol, or pigeon pea of commerce is *Cajanus indicus*, Spreng., a shrubby perennial 3 ft. to 8 ft. high, with slender woody branches furnished with trifoliate leaves and terminal racemes of pea-shaped flowers. There are two well-marked forms of the plant in cultivation, and some authors have accorded these specific rank. One of these forms (*C. flavus*, DC.) has yellow flowers, and usually only two unspotted seeds in each pod ; the other (*C. bicolor*, DC.) has yellow flowers streaked with reddish-purple and pods containing 4 or 5 seeds which are usually spotted or streaked. The seeds are sub-globular, about the size of a small garden pea, slightly compressed laterally, with a rather prominent and protruding hilum, or "eye" ; they vary in colour from greyish-white to yellow, brown or almost black, and some forms are variously speckled, blotched or streaked. Experiments made at the Labour Farm, Bihar and Orissa, between the years 1908 and 1911, proved that the *tall* erect form (*C. bicolor*) was the superior and best suited to local conditions.

Although believed to be originally native to Africa, *Cajanus indicus* has been grown in India from very

early times, and is now met with in nearly all tropical countries.

In Bombay and Bengal both varieties of the plant are cultivated; it is known as tur, tuer, togari, in Bombay, and as arhar or rahar in Bengal; in Africa it is known as the Congo pea or Congo bean and Angola pea; in the West Indies it is called no-eye pea, and in Mauritius and the Mascarene Islands it is known as ambrevade. It is also successfully grown in Southern Rhodesia and other parts of Africa, in Madagascar and Australia.

Although a perennial, the plant is usually grown as an annual, as it is liable to fungoid disease and quickly deteriorates as a perennial. If given an annual pruning, however, it will yield a crop of seeds for two or three years. It requires little cultivation and withstands drought well.

The usual method of sowing is to place 2 or 3 seeds in holes about 3 to 3½ ft. apart, covering them with about 1 in. of soil. In about a fortnight the seeds germinate, and after this takes place it is only necessary to keep the soil free from weeds until the plants become strong enough to outgrow them. Little further attention is needed until harvesting takes place.

In India the plant is cultivated principally as a subordinate crop, and there are no data on which to estimate the total acreage or yield. In the Bombay Presidency 514,000 acres were recorded as being under this crop in 1914–15, and the average yield was estimated at 634 lb. per acre, but whether this acreage referred to pure or mixed crops is not stated. In the United Provinces it is estimated that it is grown as a sole crop on 125,000 acres, and as a subordinate crop on about 3,250,000 acres, the average yield of seed being given as 560 lb. per acre when grown as a sole crop.

The pigeon pea is largely used in India for human food, and as fodder for horses and other animals when the crop is plentiful.

Gram, or Chick Pea

The plant which furnishes the Common or Bengal Gram or Chick pea is *Cicer arietinum*, Linn., a deep-rooted annual growing about 2 ft. high, forming a bushy, branch-

ing herb. The leaves are pinnate, with small ovate leaflets notched along the margins, and, in common with the other vegetative parts of the plant, covered with glandular viscose hairs. The flowers, borne singly on slender stems in the axils of the leaves, are of a light blue colour, and these are followed by short-beaked pods from ¾ in. to 1 in. in length, each of which contains as a rule two seeds. The seeds are sub-globose, more or less flattened or crinkled on four sides, with a prominent point or projection at one end; they vary in size according to variety, and may be of a dark brown, reddish-brown or yellowish-white colour. The plant is sensitive to cold, and can therefore be grown only in warm countries. It is cultivated in most parts of Southern Europe, particularly in Spain; in northern Africa, chiefly in Morocco; in Asia, particularly in India, and in Mexico.

About 500,000 acres are devoted to this crop in Spain, where the average production is estimated at 100,000 tons. The Spanish chick peas, or gabanzos as they are called in Spain, are usually of large size and whitish-yellow colour, and are valued as a food for human consumption. The area under the crop in Morocco and in Mexico is not recorded; the exports from the former country in 1912 amounted to 6,000 tons, and that from the latter, in the year 1912–13, according to the Consular Report on Mexico, was valued at £443,932.

The largest and most important producing country is India, where gram is extensively cultivated as a spring or rabi crop in the United Provinces, the Punjab, Bihar, Central Provinces and in parts of Bombay. According to the Agricultural Statistics of India, the average area under gram for the five years 1909–10 to 1913–14 was about 15,000,000 acres. The estimated yield per acre is stated as about 688 lb., but as this crop is sometimes grown mixed, a lower estimate of, say, 448 lb. per acre, would probably be safer to take in estimating the total yield. Based on the latter figure, the average annual outturn would be about 3,000,000 tons.

Experiments have recently been carried out at Pusa with a view to improving the types of chick peas grown in India, and two types have been selected, one producing

a small whitish seed and the other a small dark reddish-brown seed. The former gave an average yield for four years of 1,600 lb. of seed per acre, and the latter an average of 1,666 lb. for the same period.

The Indian chick peas are smaller than those of Europe, and are usually of a dark brown or reddish-brown colour; they are used chiefly as food for cattle in Europe, but in India they constitute one of the staple foods of the people, being eaten either parched or boiled or ground into meal. Gram and barley roasted and ground into meal is known as "suttoo," and is sold in all Indian bazaars.

As a food for horses gram has a high reputation in the East; it is, however, seldom given alone, but enters into the crushed foods that are prepared at all large centres in India. It is imported to the United Kingdom as a feeding-stuff for animals, and is said to give good results with dairy cows, when used in a mixed ration in place of beans and peas.

Gram is not a difficult crop to cultivate. The seed is usually sown 1 ft. apart in rows 2 ft. apart, or it may be broadcasted. The crop succeeds on a wide range of soils, but a light, loamy, well-drained soil is favourable to its development. During the growing period it requires a warm climate, ample sunshine and a moderate rainfall. It is recognised in India that an open, well-aerated soil is more important than soil moisture for this crop. The leaves are not suitable for use as fodder when green, as they excrete an acid secretion which is liable to do harm if eaten in excess, but they are used to a certain extent in India as cattle food after being chopped up and mixed with straw.

Indian Trade in Gram

Large quantities of gram are annually exported from India, which furnishes the bulk of the requirements of European countries. The following table shows the quantities and values of these exports for the period 1911–12 to 1916–17, and also the quantities taken by the principal importing countries.

Exports of Gram from India

		1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity	cwts.	6,934,840	2,868,384	1,301,034	465,968	640,886	761,030
„ value	£	1,831,750	704,120	415,104	150,105	224,500	274,318
To		Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
United Kingdom		2,541,141	697,767	239,625	—	226,783	50,144
Ceylon		75,222	87,068	72,407	52,000	62,098	65,628
Egypt		90,585	40,826	56,568	41,456	1,821	452,659
Straits Settlements		82,413	38,822	34,220	13,021	28,022	35,921
Mauritius		47,576	41,161	34,004	35,494	24,215	59,035
Other British countries		20,102	14,671	20,872	9,068	20,371	17,252
Germany		2,097,670	1,068,075	146,362	21,006	—	—
France		1,481,930	668,040	706,178	284,831	266,276	88,500
Other foreign countries		628,201	265,045	20,709	8,006	9,500	12,791

Included with gram in the above table is the so-called horse-gram, the seed of *Dolichos biflorus*, Linn., known in India as kulthi, which is grown chiefly in Southern India and shipped from Madras. The average annual export of gram from Madras for the period 1911–12 to 1916–17 was 12,578 cwts., so that this correction must be made in the above table to arrive at the exports of true gram or chick peas. It is possible also that some of the small-seeded Phaseolus previously referred to are included under this heading.

United Kingdom Trade in Pigeon Peas and Chick Peas

The following table shows the total quantities and values of the dhol, or pigeon peas and gram, or chick peas imported into the United Kingdom during the period 1911–16 and the principal sources from which the imports were obtained.

Imports of Dhol, or Pigeon Peas and Gram, or Chick Peas into the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	cwts.	1,112,493	2,334,388	571,916	40,126	174,403	56,720
„ value	£	325,361	728,765	188,823	15,508	90,724	34,850
From		Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
British India		1,104,608	2,307,216	570,590	35,486	167,610	56,612
Other British countries		540	—	—	960	842	10

It will be seen from these figures that so far as the trade of the United Kingdom is concerned, the supply is derived almost exclusively from British India. As a rule most of the imports are retained in the United Kingdom, as will be seen from the following table, which gives the quantities and values of the re-exports and also the principal receiving countries :

Re-Exports of Dhol, or Pigeon Peas and Gram, or Chick Peas from the United Kingdom

		1911.	1912.	1913.	1914.	1915.	1916.
Total quantity	cwts.	30,150	69,087	3,113	17,896	11,803	6,205
,, value	£	11,878	23,033	1,721	9,226	8,631	4,653
To		Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
British West Indies		11,076	4,491	1,859	7,912	2,060	3,168
British Guiana		6,473	1,988	75	6,050	6,626	637
Other British countries		43	33	—	—	159	—
Denmark (and Faroe Islands)		2,000	27,342	—	—	—	—
Netherlands		5,975	28,918	—	—	—	—
Other foreign countries		4,583	6,315	1,179	3,934	2,958	2,400

The Composition and Food Value of Pulses

The leguminous seeds used as food in this country are essentially nitrogenous foods. They contain considerably more proteins than other vegetables, including cereals, the proportion in the dried seeds ranging from about 20 to 28 per cent. in the different kinds. The amount of carbohydrates present ranges from about 45 to 60 per cent., whilst the amount of oil is low, being usually about 2 per cent. or less. Certain leguminous seeds, such as the ground nut and soy bean, are rich in oil, and these, as mentioned at the beginning of this article, are valued chiefly in Europe as oil seeds and not as a direct food. Of the pulses proper, the chick pea is richest in oil, containing about 5 per cent. Leguminous seeds are rich in mineral matter, the chief constituents of the ash being potash and phosphoric acid. The composition of the ash of peas, beans and lentils is as follows (Blyth: *Foods, their Composition and Analysis*) :

	Peas.	Broad bean.	Kidney bean.	Lentils.
	Per cent.	Per cent.	Per cent.	Per cent.
Potash	42·79	42·49	44·01	34·70
Soda	0·96	1·34	1·40	13·50
Lime	4·99	4·73	6·38	6·34
Magnesia	7·96	7·08	7·41	2·47
Ferric oxide	0·86	0·57	0·32	2·00
Phosphoric acid	36·43	38·74	35·00	36·30
Sulphuric acid	3·61	2·53	4·05	—
Silica	0·86	0·73	0·57	—
Chlorine	1·54	1·57	0·86	4·63

The pulses are generally regarded as somewhat difficult of digestion. They certainly tend to produce flatulence more than most foods, but if eaten in moderate quantities and properly prepared, that is to say, boiled until thoroughly softened or used in soups, the skin being removed in cases where it is thick, they are almost as digestible as other vegetable foods.

Although weight for weight pulses contain as much protein as meat, they have not an equal food value as regards the supply of nitrogen, since the proteins of meat are more readily absorbed than those of leguminous seeds. The actual digestibility of the proteins varies to some extent in different individuals with the kind of seed and its mode of preparation, the cooked meal or flour for example being more easily digested than the whole seeds. In one experiment which is on record, in which beans cooked in the ordinary way, whole, with the skins on, were eaten, forty per cent. of the contained proteins was unabsorbed, or four times as much as in the case of meat. In another case it was found that from two to three times as much of the protein of meat was absorbed as of that of lentils.

The following table shows the composition of the principal leguminous seeds used as food compared with other food-stuffs. Except where otherwise stated, the figures are taken from Smetham's "The Valuation of Feeding Stuffs by means of Chemical Analysis" (*Journ. Roy. Lancs. Agric. Soc.*, 1914).

Name of seed.	Water.	Oil.	Proteins.	Carbo-hydrates.	Fibre.	Ash.	Sand and Silica.	"Food Units."
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Beans, Haricot (large Japanese)	14·25	1·80	20·25	56·53	3·67	3·50	—	111
,, Rangoon Red (*P. lunatus*)	11·75	1·37	20·00	59·16	4·02	3·70	0·10	113
,, Adzuki (*P. angularis*) [1] .	10·1	0·4	19·2	62·4	4·5	3·4	—	111
,, Mung (*P. radiatus*) [2] .	10·1	2·2	22·7	55·8	4·8	4·4	—	118
,, Urd (*P. Mungo*) [2] . .	10·8	2·7	22·2	54·1	5·8	4·4	—	116
,, Moth (*P. aconitifolius*) [2].	11·2	0·6	23·8	56·6	4·2	3·6	—	118
,, Rice (*P. calcaratus*) [3] .	10·5	0·6	21·7	58·1	5·2	3·9	—	114
,, English (*Vicia Faba*) .	14·14	1·86	28·12	46·70	6·14	3·04	—	121
Peas, English	14·20	1·71	22·50	52·59	5·99	3·01	—	113
,, Canadian . . .	13·95	1·93	24·31	52·91	4·20	2·70	—	119
,, ground green, Indian .	12·15	2·23	27·06	48·05	7·66	2·85	—	121
,, Calcutta green . .	14·50	1·80	25·75	47·94	7·01	3·00	0·25	117
,, Chinese green . .	12·05	1·13	22·50	54·68	6·86	2·75	0·35	114
,, Russian . . .	17·45	1·83	23·62	48·57	5·53	3·00	0·55	112
,, green, fresh [4] . . .	74·6	0·5	7·0	16·9		1·0	—	—
Mutter peas (*Lathyrus sativus*) .	13·10	1·46	31·62	42·54	8·13	3·15	—	125
Cow peas (*Vigna Catjang*)[2] .	12·7	1·1	23·1	55·3	4·2	3·6	—	—
Lentils, average . . .	9·80	2·01	25·50	59·03	1·01	2·65	0·05	127
Gram, Bengal, or Chick peas (*Cicer arietinum*) . .	9·30	4·67	21·25	53·66	8·11	3·01	0·05	118
Pigeon peas (*Cajanus indicus*) .	12·00	2·07	20·38	55·67	6·38	3·50	0·05	112
Gram, horse (*Dolichos biflorus*) .	11·05	1·10	23·37	54·27	5·11	5·10	1·50	115
Wheat [5]	13·0	1·7	12·5	68·5	2·5	1·8	—	104
,, flour, straight or standard [5]	10·54	1·61	11·99	75·36		0·5	—	—
Rice, Burma, polished [6] . .	12·90	0·46	6·47	79·43	0·25	0·49	—	97
Oatmeal [5]	10·0	8·0	15·0	60·0	3·0	4·0	—	117
Potatoes [5]	75·0	0·2	2·0	21·0	0·7	1·1	—	26

1 "*Bulletin*" No. 119, 1914, "*U.S. Dept. Agric.*"
2 *Church*, "*Food Grains of India*," 1886.
3 *Church*, "*Food Grains of India*," Supplement, 1901.
4 "*Farmer's Bulletin*," No. 121, 1900, "*U.S. Dept. Agric.*"
5 "*Standard Encyclopædia of Modern Agriculture*," 1912.
6 "*Bulletin*" No. 10, 1913, "*Dept. Agric., Burma.*"

THE PRODUCTION OF TURPENTINE OIL AND ROSIN IN INDIA

In India turpentine-yielding trees are numerous in the forests of the Himalayas, in the United Provinces, in Assam, Burma and the Punjab. Turpentine oil and rosin have been produced in India on a small scale for some years. The oil and rosin obtained are used locally, but the quantity produced is by no means sufficient, as is evidenced by the amount of these products, particularly rosin, annually imported from the United States and

elsewhere. The chief source of Indian rosin is the Chir pine (*Pinus longifolia*, Roxb.), a species which must be distinguished from the American *P. longifolia*, Salisb., now usually known as *P. palustris*, Miller. The latter is the longleaf pine of the Southern United States, and is the chief source of American turpentine oil and rosin. The principal localities in India where tapping is now carried on are the West Almora, Naini Tal and East Almora Divisions of the Kumaun Circle, United Provinces; at Bhowali, in the Naini Tal Division, there is a Government factory for preparing turpentine oil and rosin. Another locality producing rosin is the Punjab, where a new distillery has recently been erected at Jalloo.

The rosin manufactured at Bhowali is largely taken by the paper mills in India, for use as rosin size; the turpentine is consumed mainly by the railways.

The amount of rosin annually imported into India during the years 1911–12 to 1916–17 is given in the following table. It will be seen that during this period there has been a steady decrease in the quantity of rosin imported, except in 1915–16, when there was an increase of 6,442 cwts. as compared with the previous year.

Imports of Rosin into India

		1911–12.	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity	*cwts.*	66,766	61,017	44,788	24,323	30,765	18,358
" value	*£*	62,540	60,203	33,150	15,406	22,538	21,582
From		*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom		20,353	12,287	13,088	10,162	16,447	13,006
Other British countries		139	65	38	33	58	46
United States		43,068	45,999	25,984	13,811	14,249	4,749
Belgium		...	1,180	2,844	43	...	
Japan		...	...	...	...	...	407
Germany		2,369	1,452	1,018	274	...	
Austria-Hungary		837	34	...	...		
Other foreign countries		...	...	26	...	11	...

The quantities of turpentine oil imported during the years 1912–13 to 1915–16 (figures for earlier years not available), are shown in the following table. The bulk comes from the United Kingdom, but, as in the case of the rosin from the United Kingdom shown in the preceding table, it must be mainly American or French in

origin, as no turpentine oil or rosin is produced in the British Empire, except in India itself.

Imports of Turpentine Oil into India

	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.
Total quantity . *cwts.*	20,779	16,050	11,788	7,220	6,608
,, value . £	30,630	28,319	22,531	14,175	17,707
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom .	18,818	13,485	8,962	7,034	6,309
Other British countries	379	1	2	27	2
United States . .	1,559	2,488	2,790	138	294
Germany . . .	21	74	—	—	—
Other foreign countries	2	2	34	21	3

The quantity of Indian rosin exported is small, averaging only 56 cwts. per annum during the five years 1911–12 to 1915–16, but in 1916–17 it amounted to 1,492 cwts., most of which went to Java. The re-exports of rosin (foreign merchandise) from India amounted to 700 cwts. in 1916–17, 468 cwts. in 1915–16, as against 614 cwts. in 1914–15, 1,329 cwts. in 1913–14, 1,253 in 1912–13, and 900 in 1911–12.

Distribution of Pine Forests in India

Pine forests occur in the mountains of India from Afghanistan through Kashmir, Punjab and United Provinces, to Bhutan and Assam, and in Upper and Lower Burma. Five species of pine are indigenous to India, and their distribution, according to Gamble (*A Manual of Indian Timbers*, 1902), is as follows.

Pinus longifolia, Roxb., the Chir pine, occurs in the Outer Himalaya and Siwalik Range, and also in the valleys of the principal Himalayan rivers, at an altitude of from 1,500–7,500 ft. It extends westwards to Afghanistan and eastwards to Bhutan.

P. excelsa, Wall., the kail or blue pine, is found in the temperate Himalayas at 6,000–12,500 ft. It has a similar range to *P. longifolia* but is not indigenous in Central and North-Western Kumaun and Sikkim.

P. Khasya, Royle, the dingsa or khasia pine, occurs at elevations of 3,000–7,000 ft. in the Khasi hills and hills of the Lushai country of Chittagong in Assam, and in the Shan hills and hills of Martaban in Burma.

P. Merkusii, Jungh. and de Vriese, the tinyu, is

essentially a Burmese species, and is found in the hill forests of the Shan States and Tenasserim at elevations of 500–3,500 ft.

P. Gerardiana, Wall., the neosia or Himalayan edible pine, is found in isolated areas on the inner dry and arid West Himalayas from the Niti Pass in Garhwal (United Provinces), westwards, to North Afghanistan.

So far as the commercial production of turpentine and rosin in India are concerned, the most important species is *P. longifolia*, smaller quantities being derived from *P. excelsa* and *P. Khasya*. It is not possible to state accurately the areas covered by these pines in India, as many of the forests have not been fully surveyed. According to Troup (*Indian Forest Memoirs, Sylviculture Series*, 1916, **1**, Part 1, p. 2), the area in which *P. longifolia* is more or less gregarious amounts to 2,068,530 acres (exclusive of the forests in Sikkim, Bhutan, Nepal, Mandi, the Frontier States and Afghanistan). The principal localities, with the area of *P. longifolia* forests in each case, are as follows:

Locality.	Area. *Acres.*
Gahrwal and Kumaun Himalaya, United Provinces	658,728
Tehri-Gahrwal State forests, United Provinces	308,067
Chakrata Division (Jaunsar, with Tehri-Gahrwal leased forests), United Provinces	54,055[1]
Kangra, North-East Punjab	166,947
Chamba State, North-East Punjab	10,000
Kulu, North-East Punjab	4,029
Bashahr, North-East Punjab	11,273
Simla Hills, North-East Punjab	37,401
Rawalpindi, North-West Punjab	41,000[2]
Hazara, North-West Frontier Province	23,000[3]
Kashmir, including Jammu and Poonch	692,480[4]

[1] *Workable area (for timber) only.*
[2] *Subject to revision.*
[3] *Reserved forests only.*
[4] *Roughly approximate only.*

Of the above-named regions, the tapping of pine trees for resin on a commercial scale is only being carried on at present in the Kumaun Division of the United Provinces, and in Rawalpindi, Punjab.

The area under *P. excelsa* is much less than that occupied by *P. longifolia*, the total in the United Provinces and Punjab being about 65,000 acres (*Forest Bulletin*, No. 24, 1913, p. 8). Troup estimates that

altogether *P. excelsa* covers an area of 128,000 acres in India, all of which is under the control of the Forest Department (*Work of the Forest Department in India*, 1917). According to the former publication, the largest areas, each between 13,000 and 14,000 acres in extent, are in the Hazara Forest Division, Jubal State forests (Simla Division) and Bashahr Division, all in the Punjab. Other areas in the latter Province include the upper Ravi forests, Chamba Division (8,250 acres); Pangi leased forests, Chamba State (6,000 acres); Tharoch State Forests, Simla Division (1,700 acres); and Kangra Forest Division (200 acres). In the United Provinces *P. excelsa* occupies an area of 4,740 acres in the Tehri-Gahrwal leased forests and 3,500 acres in the Government forests in Jaunsar Bawar.

As already mentioned, *P. Khasya* occurs in Assam, where the available area is stated to be 33 sq. miles, and in Burma. In the latter province, *P. Merkusii* also occurs. The following particulars as to the area under these two pines in Burma are taken from *Forest Bulletin*, No. 24, 1913, pp. 2–3:

Locality.	Area. Sq. miles.	Species of Pine.
Tenasserim Circle	50	*P. Khasya* (pure and mixed with deciduous trees).
Mongtung (Northern Shan States)	75	Not stated.
Myelat States (Southern States)	300	*P. Khasya.*
Lawksawk State (Southern States)	300	,,
Loilong and Mongpai State (Southern States)	300	,,
Mongpawn and Laihka (Southern States)	150	,,
Mong Kung State (Southern States)	300	,,
Hsatung State (Southern States)	50	*P. Merkusii.*
Mongnai State (Southern States)	100	Both species; probably 70 per cent. *P. Merkusii* and 30 per cent. *P. Khasya.*
Mawkmai State (Southern States)	100	
Mongpan State (Southern States)	600	
Kengtung (Mongpu and Monghsat) (Southern States)	800	

The Deputy Conservator of Forests in the Southern States considers that of the 3,000 sq. miles under pine in his division, 1,400 sq. miles might be worked under the present conditions of transport.

In addition to those included in the foregoing table, very large forests of pine exist in the Maing Lon State

to the south of Mogôk (Southern Circle), and pine is also said to occur in the Pakôkku Hill Tracts and Chin Hills, but the area in these cases is not known. There is an inconsiderable pine area in the Northern Circle of Burma, the total area in the Myitkyina, Lower Chindwin, Myittha, and Upper Chindwin Divisions being not more than 6 sq. miles.

In the case of all the species of pine referred to in the preceding pages, the area which can be profitably worked at present for the production of rosin and turpentine is considerably less than that given, but no figures of the available area appear to have been published.

Present Position of the Turpentine and Rosin Industry in India

As already mentioned, the tapping of pine for the production of oleo-resin on a commercial scale is being carried on in the United Provinces and in the Punjab. In both cases the tapping of the trees and the distillation of the oleo-resin are being conducted by the respective Forest Departments, whilst the sale of the turpentine and rosin in both Provinces is under the control of the manager of the distillery in the United Provinces.

United Provinces.—According to E. A. Smythies ("The Resin Industry in Kumaon," *Forest Bulletin*, No. 26, 1914), the first experiments on the utilisation of the extensive pine forests of Kumaun, in the United Provinces, for the production of turpentine and rosin, were conducted by the officers in charge of the Forest College at Dehra Dun about 1890. By 1895 it had been established that oleo-resin could be obtained in workable quantities from the Chir pine (*Pinus longifolia*, Roxb.), and that the turpentine and rosin obtained were readily saleable. In the following year tapping operations were started in the Naini Tal Forest Division, a commencement being made with 10,000 trees. A distillery was erected at Bhowali, where there is an excellent supply of cold water, whilst the surrounding oak and pine forests afford adequate supplies of fuel and timber. This distillery is now under the control of a

European manager, and new plant has been installed, which was worked for the first time in the year 1914–15. It is proposed to erect a second distillery in Eastern Kumaun, near Tanakpur.

The growth of the industry was at first comparatively slow, the output of crude oleo-resin rising from 125 tons in 1903–4 to 515 tons in 1911–12, but when, after fifteen years' working, it had been established that the tapping operations, as carried out by the Department, did no harm to the standing trees or the forest, arrangements were made to develop the industry as completely and rapidly as possible. Since 1911–12 there has been a marked increase in the output of crude oleo-resin, the quantity produced in each subsequent year being as follows: 1912–13, 971 tons; 1913–14, 1,580 tons; 1914–15, 1,768 tons; 1915–16, 2,089 tons.

The total area of forest worked in 1915–16 amounted to 49,135 acres; 981,906 trees were tapped, and the number of blazes or channels was 1,591,460. The yield of crude oleo-resin per 100 channels during the year amounted to 294 lb., being 97 lb. more than in 1914–15. The output of rosin from the Bhowali distillery in 1915–16 was 1,285 tons, and of turpentine 80,390 gallons. The result of the year's working showed a net profit of £7,715, as compared with £4,493 in 1914–15 and £3,710 in 1913–14. The net profits in 1915–16 would have been greater by £3,000 if it had not been for a serious fire at the factory during the year.

The new distilling plant at Bhowali has proved successful. Uniform and high grades of turpentine and rosin are produced for which there is now a steady demand in India. Four grades of oil are made, and according to the *Report on Forest Administration in the United Provinces for* 1915–16 there was a keen demand for Grade III during the year which could not be fully met. Possible markets outside India for the products are also receiving the attention of the Forest Department, particularly in Java, where 10,000 tons of rosin are consumed annually, and an order for 1,200 gallons of turpentine and 477 tons of rosin from that country was executed during 1915–16.

The chief difficulty experienced in connection with the industry in Kumaun is the transport of the crude oleo-resin to the factory. Some of the areas being tapped are at a distance of 80 miles by cart-road and a further 20 miles by foot-path from the distillery. Altogether, tapping operations for the supply of oleo-resin to the Bhowali distillery extend over an area of not less than 2,000 sq. miles, but of this not more than 400 sq. miles are pine forest. The difficulty in obtaining sufficient carts for the transport of the oleo-resin to the rail-head is said to necessitate the employment of mechanical transport of some kind, such as tank lorries, if the roads can be sufficiently improved to take them.

The tapping of pine trees was, until recently, conducted also in the Chakrata Division of the United Provinces, 50 tons of oleo-resin being collected in 1915–16. There is a distillery at Kalsi, but the stills are obsolete, and it was closed down in 1914. The trade during the next year or two was in oleo-resin only, but the demand for this fell off, and it would not pay to transport it by rail to Bhowali for treatment. Tapping has therefore now been discontinued in this division, and it is stated that unless a cheap method of extraction is discovered, the leased forests of Tehri-Garhwal will not pay to tap (*Rep., Forest Admin., U.P.*, 1915–16).

Punjab.—Tapping operations in the Punjab are at present confined to the Rawalpindi forests in the north-west part of the province. There are, however, extensive areas available in Kangra in North-East Punjab which were at one time worked, but it is not proposed to recommence tapping these until there is a ready market for larger supplies of turpentine in India. As in the case of the United Provinces, the chir pine (*Pinus longifolia*) furnishes the whole of the oleo-resin obtained in the Punjab. Experiments have been conducted in tapping the kail pine (*P. excelsa*) in Bashahr, but the results were not very satisfactory. The yield of oleo-resin was relatively small as compared with that from the chir pine, whilst the cost of extraction from the comparatively remote kail areas of Bashahr raised the cost of production of the turpentine and rosin to a high figure. It was

decided, therefore, not to work the kail forests for the present (*Progr. Rep., For. Admin., Punjab,* 1912–13).

The pine forests of Kangra appear to have been first worked by Departmental agency for oleo-resin in 1897–8, a factory being erected at Nurpur in 1899. During the five or six years the factory was working, from 150–180 tons of oleo-resin were distilled annually, yielding 110–150 tons of rosin and 7,000–9,000 gallons of turpentine. After the first two years the factory showed a fair profit, but as there was a good demand for the oleo-resin, and as the latter could be sold to better advantage than could the finished products, it was decided to close the factory from April 1, 1905, and that tapping in Kangra should be restricted to trees destined to be felled, except for a small experimental area.

In 1909–10 tapping was started in Rawalpindi, and in the following year a central factory was established at Shahdara on the Ravi River, 4 miles north of Lahore, with a plant capable of dealing with 10,000 maunds (367 tons) of oleo-resin per annum. In 1914 the factory was seriously damaged by floods, and it was decided to remove it to Jalloo railway station, 9 miles east of Lahore, on the Lahore–Amritsar railway, where an entirely new plant of French design was installed. In 1915–16, the first complete year of working, 717 tons of oleo-resin were distilled at Jalloo, yielding 447 tons of rosin and 31,445 gallons of turpentine. Altogether 550,000 blazes have now been set up in the Rawalpindi forests and 25,000 maunds (918 tons) of oleo-resin are to be dealt with annually.

Assam and Burma.—Although there are considerable areas of pine forests in Assam and Burma (see p. 548), tapping of the trees does not yet appear to be carried on in either province. With a view to establishing the industry in Assam, however, an area of 24 sq. miles in the Mylliem State was reserved for the growth of *Pinus Khasia* in 1914–15, and seed has also been supplied by the Forest Department to the native chiefs of other small states in the Khasi Hills who had set apart areas for the growing of pine.

Methods of Tapping and Distillation in India

Many of the forest officers who started the oleo-resin industry in India were trained in the French forestry schools, and the "cup and lip" method of tapping pines in use in France was naturally adopted in India. This method is usually regarded as better than the American "box" system, as the best possible yield of oleo-resin is obtained with the minimum risk of injury to the tree.

In Kumaun (*Forest Bulletin*, No. 26, 1914), tapping commences about March, and the cut is freshened about every 6 or 7 days (five times a month) throughout the summer. The tapping continues for five years and the trees are then rested for ten years, so that only one-third of the total area of pine forest is actually being worked at any one time. Most of the areas in Kumaun are being tapped lightly, one channel being put on trees between 3 ft. 6 in. and 4 ft. 6 in. in girth, two channels on those between 4 ft. 6 in. and 6 ft., and three channels on those over 6 ft. in girth. Those trees which are to be felled within five years, however, are tapped heavily, as many as eleven channels being put on them in some cases. A group of 2,000 trees which were "tapped to death" gave a yield of 450 cwts. of oleo-resin during 1913, whilst under light tapping not more than 120 cwts. could have been expected.

The methods of tapping adopted in the Punjab agree essentially with those in Kumaun. Experiments have shown, however, that a short freshening period is economically sound, and an interval of four days between successive tappings is the standard now adopted in the Punjab.

Troup (*The Work of the Forest Dept. in India*, 1917) states that "it was in the factories and in the selection and devising of manufacturing methods best suited for the distillation of the Indian pine resin that the Forest Department found its hardest task, a task in which the Forest Research Institute at Dehra Dun and the Imperial Institute, London, gave much helpful advice and assistance." It was found that the comparatively primitive, direct fire-heat apparatus used in the distillation of the

American oleo-resin was unsuitable for Indian oleo-resin, and in order to procure turpentine and rosin of good quality it was necessary to employ steam distillation, as is done in France.

The following description of the process of distillation adopted at the Jalloo factory in the Punjab is taken from Troup's publication previously referred to. The methods employed at the Bhowali factory in the United Provinces are somewhat similar, but the plant is not quite so modern, a defect which it is hoped to remedy at the close of the war; a detailed description of the methods used at Bhowali is given in *Forest Bulletin*, No. 26, 1914.

The oleo-resin as received from the forests is first melted by steam, a little turpentine from a previous distillation being added to facilitate the process. On standing, the water, dirt and other impurities sink to the bottom of the vat, and the clean oleo-resin is drawn off into storage tanks, whence a measured quantity is passed into the still. The latter is steam jacketed and kept hot by steam under pressure, so that any desired temperature may be attained. Steam is injected into the still, and the turpentine and water vapours which distil over are first passed into a trap still to catch any oleo-resin or rosin that may have come over and then into a condenser, the liquid turpentine and water being next separated in a mechanical separator. To ensure standard qualities, the turpentine is redistilled in a subsidiary still, and passed through lime water to remove any traces of resinous acids; it was formerly dehydrated by filtration through anhydrous sodium sulphate, but as this process is thought to be a possible source of contamination, the last traces of water are now removed by storing the turpentine for a time in bulk. In order to dispense with redistillation, experiments are in progress on fractionating the distillate during the primary distillation. The turpentine is put up for sale in 5-gallon drums bearing distinctive stencil marks, bung-hole discs and labels to prevent tampering by retail traders.

The hot rosin in the still is drawn off by means of a valve and transferred to the rosin shed, where it is filtered

through a layer of cotton wool and then run into casks, bags or tins while still moderately hot and fluid. The rosin is graded according to American standard into pale, medium and dark shades.

Future Position of the Industry

It is anticipated that the Bhowali factory will, in a few years' time, be in a position to supply about 60 per cent. of the total Indian consumption of turpentine, and well over 80 per cent. of the rosin consumption of India. In addition it is anticipated that the distillery which it is proposed to erect at Tanakpur will have an approximate output of 25,000 gallons of turpentine, while the departmental operations in the Punjab will ultimately give a further 50,000 gallons, making a total of 200,000 gallons per annum and 4,000 tons of rosin. This will absorb practically all the workable forests of chir pine under the Forest Department.

To-day India is herself producing about 1,800 tons of rosin and 112,000 gallons of turpentine towards her annual requirements. Troup (*The Work of the Forest Dept. in India*, 1917) points out that at present the industry is practically in the position of having to retard or accelerate its expansion with direct reference to the speed with which the remainder of the Indian market can be secured and outside markets such as Java, China, etc., developed. It is here that closer co-operation with the trade interests of India is necessary, and more active measures have to be adopted to advertise Indian rosin and turpentine. It may be added that if transport were improved and cheapened, the cost of Indian turpentine and rosin might be materially reduced and the possible markets greatly increased.

As regards the financial aspect of the resin industry in India, E. S. Smythies (*Indian Forester*, April 1916) states that a normal fully stocked chir forest under favourable conditions, such as obtain near Naini Tal, may be expected to produce a net annual revenue of Rs. 16 to Rs. 20 (21*s.* 4*d.* to 26*s.* 8*d.*) per acre. In areas, which are not so favourably situated, and from which only one-third of the gross receipts may be taken as net

profit (and this would apply to a very large proportion of the forests at present being worked), the financial result from the industry alone would still amount to Rs. 5 to Rs. 7 (6s. 8d. to 9s. 4d.) per acre per annum net profit. Mr. Smythies estimates that the industry in India should in course of time produce a gross annual revenue of Rs. 30 to Rs. 35 lakhs (£200,000 to £233,333).

Characters of Indian Turpentine and Rosin

The composition and characters of Indian turpentine have been repeatedly the subject of investigation at the Imperial Institute, as well as at the Forest Research Institute, Dehra Dun, India. As long ago as 1896 a preliminary report by Professor H. E. Armstrong, F.R.S., on the oils obtained from the resin of *Pinus Khasya* and *P. Merkusii* was forwarded to India by the Imperial Institute (see *Technical Reports from the Imperial Institute*, 1903, p. 167), and since then reports on the crude oleo-resin, rosin and turpentine of *P. longifolia*, *P. excelsa* and *P. Khasya*, have also been supplied. In the following pages a summary of the results of these investigations is given; for further details reference may be made to *Selected Reports from the Scientific and Technical Department, Imperial Institute*, Part II, *Gums and Resins* (*Colonial Reports—Miscellaneous*, No. 63 [Cd. 4971], 1909, p. 195) and this BULLETIN (1911, **9**, 8 and 1912, **10**, 539).

Pinus longifolia

Oleo-resin.—A sample of oleo-resin from the Naini Tal Division, United Provinces, was received in 1908. The botanical origin of the material was not stated, but it was doubtless the product of *P. longifolia*. On steam distillation it gave a yield of only 12·7 per cent. by weight of turpentine oil, so that there had evidently been a considerable loss of oil during storage and transit. The yield of oil obtained on a commercial scale at the Bhowali distillery varies from 17½ to 19 per cent. according to the quality and freshness of the oleo-resin. A second sample examined subsequently gave a yield of 19 per cent. of oil as the result of long-continued distillation, a figure which is more in accord with that obtained in India.

Turpentine Oil.—In all, six samples of oil prepared in India have been submitted to detailed examination at the Imperial Institute, as follows:

No. 1.—From the Jaunsar Division, United Provinces. Received in 1907.

No. 2.—Prepared at the Bhowali distillery. Received in 1910. This sample had been prepared by distilling the resin with 70 per cent. methylated spirit over a gentle fire for $3\frac{1}{2}$ hours.

No. 3.—This was prepared in a similar way to No. 2, but the distillation was carried out more rapidly, being completed in two hours.

No. 4.—Prepared at the Forest Research Institute, Dehra Dun. Received in 1911. In this case the oleo-resin was mixed with acetic acid and gently warmed, so that it became quite liquid, and was then steam distilled. The sample received was the crude oil.

No. 5.—Prepared as in the case of No. 4, but rectified.

No. 6.—This was part of a trial consignment of turpentine oil sent from India to a firm of varnish makers in London.

Samples No, 2, 3, 4 and 5 were prepared in the course of experiments conducted by the chemist at the Forest Research Institute, Dehra Dun, with a view to improving the quality of Indian turpentine. A detailed account of these experiments is given in *Indian Forest Records* (1912, 4, 1).

The specific gravity and optical rotation of the oils as received at the Imperial Institute were as follows:

	1.	2.	3.	4.	5.	6.
Specific gravity at $\frac{15^\circ \text{ C.}}{15^\circ \text{ C.}}$	0·869	0·871	0·868	0·868	0·866	0·867
Optical rotation in 100 mm. tube	$-5^\circ 2'$	$-0^\circ 45'$	$-2^\circ 10'$	$+0^\circ 20'$	$-0^\circ 40'$	$-7^\circ 20'$

In the case of Sample No. 1, a portion of the oil was distilled to remove the comparatively non-volatile matter, and the distillate was submitted to a long series of fractional distillations to separate the volatile constituents from one another. These distillations were made under diminished pressure, approaching a vacuum, so that the boiling was effected at temperatures not exceeding

100° C. in order that the constituents might not be altered by the heat applied.

The non-volatile matter amounted to about 6 per cent., but as the amount of non-volatile matter in turpentine oil slowly increases owing to atmospheric oxidation, it may have been less when the oil was first prepared.

The volatile constituents were separated into two portions, differing considerably in their boiling-points.

The portion with the lower boiling-point amounted to one-third of the total volatile oil, and was found to be laevo-pinene. Purified portions had a boiling-point of 157·5° C., a specific gravity at 15° C. of 0·862 compared with water at the same temperature, and a specific rotatory power $[\alpha]_D = -42°$.

The remaining two-thirds was much less volatile and appeared to be mainly composed of a turpentine oil having a boiling-point of 173° C., a specific gravity at 15° C. of 0·867 as compared with water at the same temperature, and a specific rotatory power $[\alpha]_D = +14° 6'$.

Samples 2–6 were fractionally distilled with the results given in the following table:

Percentage of Total Sample by Volume

Fraction boiling at:	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
165° C. or below	1	1	—	—	—
165° C. to 167° C.	54	55	43	56	32
167° C. to 170° C.					39
170° C. to 173° C.	25	28	40	33	14
173° C. to 175° C.					4
Above 175° C.	12	9	11	6	7
Residue and loss	7	6	6	5	4

Optical Rotation in 100 mm. Tube

Fraction boiling at:	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
165° C. or below	−9° 45′	—	—	—	—
165° C. to 167° C.	−5° 15′	−7° 15′	−5° 25′	−4° 40′	−14° 5′
167° C. to 170° C.					−8° 50′
170° C. to 173° C.	+2° 0′	+0° 20′	+2° 0′	+3° 5′	−2° 15′
173° C. to 175° C.					—
Above 175° C.	+6° 35′	+7° 5′	+8° 5′	—	—
Residue and loss	+10° 45′	+17° 25′	—	—	—

The above figures show that these samples, yielding practically no distillate below 165° C., are quite different from American turpentine oil, which should yield not less than 70 per cent. by volume between 155° and 160° C. They more nearly resemble Russian turpentine oil among those on the English market, as the following figures,

which have been recorded for two samples of commercial Russian oil, indicate :

		1.	2.
Specific gravity at $\frac{15·5° C.}{15·5° C.}$		0·866	0·884
Optical rotation in 100 mm. tube		+ 14° 29′	+ 16° 20′
Fraction boiling at :			
155° C. to 160° C.	*per cent.*	4	2
160° C. to 165° C.	,,	12	16
165° C. to 170° C.	,,	43	36
170° C. to 175° C.	,,	20	18
175° C. to 180° C.	,,	11	7
180° C. to 185° C.	,,	3	4
185° C. to 190° C.	,,	2	2

In order to investigate further the turpentine oil of *P. longifolia*, a sample of oleo-resin was submitted to steam distillation at the Imperial Institute. The first fraction of distillate had a specific gravity of 0·867 at 15° C./15° C. and a rotatory power in a 100 mm. tube of $[\alpha]_D = +0° 10'$, but the density and also the rotatory power of the subsequent fractions gradually rose, until a distillate was obtained having a density of 0·918 and a rotatory power of $[\alpha]_D = +21°$.

By this long-continued distillation 19 per cent. by weight of turpentine oil was obtained, and probably the yield could have been slightly increased by carrying the distillation still further. As, however, the later distillates are of high specific gravity, it would not be advisable to carry the distillation to this point in actual practice, and the manufacturing yield from oleo-resin of the quality of the sample experimented with should not exceed 166 c.c. of oil, weighing 144 grams, from 1,000 grams of the oleo-resin, *i.e.*, about 14 per cent. by weight. This oil, which should have a specific gravity at 15° C./15° C. of 0·867, should be purified by redistillation before being put on the market as rectified turpentine oil.

The first fraction of oil obtained on distillation of the oleo-resin, having a rotatory power of $[\alpha]_D = +0° 10'$, and a specific gravity of 0·867 at 15° C./15° C., was submitted to repeated fractional distillation under reduced pressure, and two products were thus obtained, viz. :

(1) Laevo-pinene, the characteristic terpene of French turpentine oil, which has a boiling-point of 156° C. and a rotatory power of $[\alpha]_D = -37°$. It was estimated that

this laevo-pinene amounted to 25 per cent. by weight of the entire oil, or a little less.

(2) A high-boiling product with a boiling-point of 173° C., a rotatory power $[\alpha]_D = +12° 20'$, and a specific gravity of 0·867 at 15° C./15° C. This constituent when exposed to the air oxidises much more rapidly than laevo-pinene. A portion of this high-boiling liquid of such a high degree of purity that the rotatory power was not changed by fractional distillation was submitted to fractional crystallisation to see if any separation could be effected, liquid air being used to obtain the necessary degree of cold. The oil was twice frozen, but it was found that the two crops of crystals and the mother liquors all had the same rotatory power as the portion of liquid taken for freezing, which thus appeared to be a single substance. When the pure terpene from the high-boiling fraction was treated with dry hydrochloric acid gas it yielded crystals of sylvestrene dihydrochloride, but when tested with acetic anhydride and strong sulphuric acid it did not give the blue colouration of sylvestrene. Its specific gravity, moreover, was higher than that of sylvestrene, which is 0·848 at 20° C.

It would therefore seem that the high-boiling portion of the oil is mainly a single terpene, which is not sylvestrene, but nevertheless yields sylvestrene dihydrochloride when it unites with hydrochloric acid; a circumstance analogous to that observed in the case of pinene which in a similar way yields camphene hydrochloride. The liquid thus appears to be a terpene related to sylvestrene and hitherto undescribed, and it may possibly contain other terpenes very difficult to separate.

The results of the examination of the oil prepared at the Imperial Institute confirm those obtained with turpentine oil distilled in India. To sum up, therefore, it has been shown that *P. longifolia* oil consists of from 25 to 33 per cent. by weight of *l*-pinene, the rest being principally a terpene, boiling at 173° C., which yields sylvestrene dihydrochloride when treated with hydrogen chloride. If the distillation of the oleo-resin is pushed too far, other constituents, which do not distil at temperatures below 175° C., are included in the oil.

The turpentine oil from *P. longifolia*, containing as it does normally a large proportion of terpene boiling at 173° C., must always be inferior to the best French and American turpentine oils, consisting almost wholly of pinene boiling at 156° C. It is therefore very important that the inclusion in the Indian oil of constituents, which do not distil below 175° C., should be avoided, and this can only be done by carefully controlling the distillation of the oleo-resin and stopping it before these undesirable constituents begin to appear in the distillate. This conclusion is also borne out by the results of experiments recorded in *Indian Forest Records* (1912, 4, 35). Oil produced by water distillation was collected in four fractions. The first three fractions, representing about 70 per cent. of the whole, were mixed and fractionated, and 75 per cent. passed over below 172° C. and 82·5 per cent. below 180° C. Of the fourth fraction, only 27·5 per cent. passed over below 172° C. and 59·5 per cent. below 180° C. The residue above 200° C. amounted to 12·5 per cent. in the case of the first three fractions and 29 per cent. in the case of the fourth.

The quality of the Indian oil can be greatly improved by redistillation, and, as already mentioned, that now being produced by steam distillation at Jalloo and Bhowali is redistilled before being placed on the market.

Experiments were made at the Imperial Institute to compare the behaviour, on exposure to air, of the sample of rectified Indian turpentine oil referred to above (No. 5), with that of a sample of ordinary rectified turpentine oil purchased in London. It was found that the Indian oil evaporated more slowly, oxidised much more rapidly, and gave more oxidised residue than the oil purchased in London. In these experiments, quantities of 10 c.c. of each oil were exposed in glass dishes 8 cm. wide, with vertical sides 3·6 cm. high. In six days the oil bought in London had evaporated, leaving an immobile film of thick liquid, whilst the Indian oil left a layer of syrupy liquid, which became immobile two or three days later. After seven weeks the residue left by the Indian oil was still sticky where the layer was thick, and "tacky" where it was thin, whereas the London sample had dried

to a thin, "tacky" layer. The Indian oil finally left 1¼ grams of residue, whilst the London oil left only ¼ gram.

The properties of the two oils were also compared by using them to prepare solutions of zinc resinate. On leaving the oils for seventeen days in contact with an excess of the resinate, the oil purchased in London proved to be the more powerful solvent of the two, giving a very thick syrupy liquid, which had to be diluted with more oil before it could be used; whilst in the case of the Indian oil only a thin syrupy solution was obtained. This thin solution, however, when painted on sized wood gave a very satisfactory varnished surface, so that it appears that the Indian oil can be used quite well for making certain kinds of varnish.

Rosin.—Two samples of rosin or colophony of *P. longifolia* prepared at Naini Tal, United Provinces, have been examined at the Imperial Institute, the first being received in 1905 and the second in 1910. No information was supplied as to the method employed in preparing the first sample, but the second had been prepared by heating the rosin as it came from the still with 10·15 per cent. of its weight of crystalline alum, and then separating it again by filtration. A description of the method employed in the case of the latter sample, together with the results of other experiments on the clarification of Indian rosin, is given in *Indian Forest Records* (1912, 4, 75).

Sample No. 1 was rather dark in colour, but No. 2 (clarified with alum) consisted of masses of transparent pale brownish-yellow rosin having the usual appearance and properties of rosin of good quality.

The results of the examination of the samples, compared with typical samples of American and Bordeaux rosins of commerce, are shown in the following table:

	Indian rosin. 1	Indian rosin. 2	American rosin.	Bordeaux rosin.
Melting point	75–85° C.	74° C.	—	—
Specific gravity	1·067	—	—	—
Moisture . . . *per cent.*	—	0·80	—	—
Ash . . . „	0·125	0·15	—	—
Saponification value [1]	190	184	184	184
Acid value [1]	165	174	176	175
Unsaponifiable matter, *per cent.*	5·0	—	6·5	—
Specific rotation	+ 9° 40′	—	+ 29° 5′	0·0

[1] *Milligrams of potassium hydroxide required for 1 gram of rosin.*

These results show that there is little difference in composition between Indian rosin and that produced in the United States and France. Provided that the composition is satisfactory, the value of rosin depends primarily on its colour, and on this basis Sample No. 1 would rank as of low grade. Sample No. 2 was of much better quality, and although not quite so pale as the best Bordeaux rosin, it would be classed with the "water white" grades of American rosin; it was valued by a firm of merchants at £14–£15 per ton in the United Kingdom, the current value of American rosin of similar colour and quality at the time of valuation being £14 9*s*. per ton.

It is clear, therefore, that Indian rosin if properly prepared is little, if at all, inferior to American and French rosins. It is at present mainly used in India in soap-making and paper-making.

Pinus excelsa.

Oleo-resin.—A sample of the crude oleo-resin of *P. excelsa* from the Punjab, received at the Imperial Institute in 1908, gave a yield of 20·6 per cent. by weight of turpentine oil. The latter had a specific gravity at 15° C./15° C. of 0·8613, and an optical rotation in a 100-mm. tube of + 35° 25′. A specimen examined at Dehra Dun gave a yield of 18·82 per cent. of oil, with a specific gravity of 0·8583 at 20° C. (*Forest Bulletin*, No. 24, 1913, p. 8).

Turpentine Oil.—A sample of the oil produced at Dehra Dun was examined in 1912. It was of pale yellow tint, and had an odour resembling that of the best American grades of turpentine oil, but rather more pleasant. It had the following constants:

Specific gravity at $\frac{15^\circ \text{ C.}}{15^\circ \text{ C.}}$	0·862
Optical rotation in 100 mm. tube	+ 36° 40′
Specific rotatory power $[\alpha]_D$	+ 42° 30′

The oil was fractionally distilled with the following results:

Fraction boiling at:	Per cent. of oil distilled.	Optical rotation in 100 mm. tube.
157° C. to 158° C.	74	+ 37° 10′
158° C. to 160° C.	16	+ 36° 15′
160° C. to 170° C.	7	+ 34° 10′
Residue and loss	3	—

From these results it was clear that this sample of turpentine oil was of good quality; 90 per cent. of the oil boiled within the narrow range of 155° to 160° C., and consisted mainly of dextro-pinene.

A sample of the redistilled oil was submitted to a firm of varnish-makers, and samples of the oil in its original condition to two firms of merchants. The reports obtained indicated that the oil, if redistilled before shipment in order to render it colourless, would be readily saleable in the United Kingdom. The merchants would not, however, express an opinion as to the exact commercial value of the oil without having an opportunity of seeing and testing bulk samples, and they suggested that for this purpose 1 ton of the oil should be shipped to London for trial. They pointed out that this would also afford an opportunity of introducing the oil to manufacturers and of ascertaining its actual value for technical purposes.

The yellow tint exhibited by the oil examined at the Imperial Institute could be easily removed by redistillation, or it is possible, as suggested in *Forest Bulletin*, No. 24, 1913, p. 7, that a catch still between the main still and the condenser would arrest the impurities to which the discolouration is due. *P. excelsa* oil, when freed from the yellow colouration, is quite equal in quality to the best grades of French and American turpentine oil, and it is very probable that technical trials will show that the oil is equally suitable for industrial purposes.

Rosin.—A specimen of rosin prepared at the Imperial Institute from the crude oleo-resin of *P. excelsa* gave the following results on examination:

Saponification value [1]		194
Acid value [1]		170
Unsaponifiable matter	*per cent.*	9·0
Specific rotation		− 4° 48′

[1] *Milligrams of potassium hydroxide required for 1 gram of rosin.*

This rosin was of good quality, and quite suitable for use in soap-making and other industries.

Pinus Khasya

Oleo-resin.—The sample of oleo-resin of *P. Khasya* from Burma, reported on by Professor H. E. Armstrong

in 1896, was a grey, thick, pasty mass. It gave a yield of about 13 per cent. by weight of oil on steam distillation, and had evidently lost oil since it was collected, as a sample previously examined by him had given a yield of 17 per cent. of oil. Resin from the Southern Shan States, examined at Dehra Dun in 1911, gave a yield of 17·8 per cent. of oil (*loc. cit.*, p. 5).

Turpentine Oil.—Judging from the results so far recorded, the turpentine obtained from the resin of *P. Khasya* from Burma differs in some respects from that obtained in Assam. The following table shows the constants of the oil from these two localities and the results of fractional distillation :

		Burma.		Assam.	
		1. (Armstrong.)	2. (Dehra Dun.)	3. (Imperial Institute.)	4. (Dehra Dun.)
Specific gravity . . .		0·8627 at 20° C.	0·8550 at 20° C.	0·870 at 15° C.	0·8733 at 15° C.
Optical rotation in 100 mm. tube		—	—	− 4° 50′	− 2°
Specific rotatory power $[\alpha]_D$ =		+ 36° 28′	+ 34° 8′	− 5° 30′	—
Fraction boiling at :					
150° C. to 155° C.	*per cent.*	—	76	—	3·5
155° C. to 160° C.	,,	—	20	—	67·0
160° C. to 165° C.	,,	—	—	—	24·0
162° C. to 163° C.	,,	—	—	25	—
163° C. to 165° C.	,,	—	—	57	—
165° C. to 169° C.	,,	—	—	11	—
Residue and loss	,,	—	4	7	5·5

Professor Armstrong did not give the results of fractionation, but stated that the oil boiled within a narrow range of temperature, near to 155° C., and that it appeared to contain a certain proportion of a constituent with a higher boiling-point.

The specific gravity and optical rotation of the oil examined at the Imperial Institute were as follows :

Fraction boiling at :	Specific gravity at $\frac{15° C.}{15° C.}$	Optical rotation in 100 mm. tube.
About 162° C. to 163° C. . .	0·869	− 1° 50′
,, 163° C. to 165° C. . .	0·870	− 4° 40′
,, 165° C. to 169° C. . .	0·871	− 10° 40′
Residue and loss	0·895	− 7° 30′

These results show that the oil of *P. Khasya* is a moderately good turpentine oil, boiling within a fairly narrow range of temperature. The optical rotations

indicate, however, that it is a mixture of terpenes, and in this respect it differs from American and French turpentine, which consist mainly of *d*- and *l*-pinene respectively. The standards which have been suggested or adopted at different times for grading American turpentine oil show a good deal of variation. Coste (*Analyst*, 1908, 33, 219) considers that a good American "box" turpentine oil should comply with the requirement that 70 per cent. of the oil by volume should distil between 155° and 160° C. More recently it has been recommended (*Bull.* No. 135, 1911, *Bur. Chem., U.S. Dept. Agric.*) that the following grades of American oil should be recognised: No. 1, of which 95 per cent. should distil below 170° C.; No. 2, of which 90 per cent. should distil below 170° C.; and No. 3, of which 60 per cent. should distil below 170° C. It is evident therefore that, apart from its colour, the oil of *P. Khasya* did not compare favourably with the best grades of American turpentine, but was quite equal to the lower grades.

The oil examined at the Imperial Institute had a yellow tint, but this could be easily removed by redistillation.

A sample of the redistilled oil was submitted to a firm of varnish-makers, and samples of the oil in its original condition to two firms of merchants together with the oil of *P. excelsa* and the remarks given on p. 564 with reference to the latter oil apply equally to that of *P. Khasya*.

Suitability of Indian Turpentine and Rosin for the British Market

The United Kingdom at present depends on foreign countries for its supplies of turpentine and rosin, the chief source of supply being the United States. There is a comparatively small import of rosin recorded in the Trade Returns as coming from British countries, but it is improbable that this originated in the countries named, as no pine rosin is produced within the Empire except in India. The imports of rosin and turpentine into the United Kingdom in recent years are shown in the following table:

Imports of Rosin into the United Kingdom

	1912.	1913.	1914.	1915.	1916.	1917.
Total quantity *cwts.*	1,641,376	1,758,067	1,548,184	2,071,963	2,001,815	1,726,573
,, value £	1,248,524	1,120,652	822,093	1,200,483	1,888,887	2,466,254
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British countries .	18,758	27,035	563	12,523	—	Figures not available.
United States .	1,001,447	1,322,026	1,072,228	1,082,312	1,514,001	
France . . .	354,836	193,440	323,637	757,129	291,604	
Belgium . . .	69,059	55,268	24,682	—	—	
Portugal . . .	56,012	29,002	19,224	45,044	50,156	
Spain . . .	88,194	91,163	84,334	165,452	140,854	
Other foreign countries	53,079	40,133	23,516	9,503	4,300	

Imports of Turpentine into the United Kingdom

	1912.	1913.	1914.	1915.	1916.	1917.
Total quantity . *cwts.*	656,216	560,330	348,206	529,517	430,780	221,192
,, value . . £	1,028,007	768,800	542,205	903,381	903,384	620,747
From	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
British countries . .	38	—	—	—	—	Figures not available.
United States . .	575,131	476,400	294,509	418,050	368,575	
France . . .	17,986	33,656	19,491	40,506	5,229	
Russia	48,713	32,648	21,006	3,899	—	
Germany . . .	3,073	5,293	2,914	—	—	
Other foreign countries .	11,275	12,333	10,286	67,062	56,976	

It will be seen therefore that there is an ample market in the United Kingdom for any surplus of either turpentine or rosin that may be available for export from India. Whether any will be available for export to this country in the future remains to be seen. The production of adequate quantities of turpentine of good quality in India may stimulate the varnish and paint industries, so that the whole supplies may be taken up in the country, and in any case it is likely that the nearer markets, such as Java, China and Australia, will be supplied first. Further, comparatively little is definitely known as to the quantity of oleo-resin that may be available for distillation in India, particularly as regards *P. excelsa*, which yields the best oil.

There seems no doubt that if supplies should be available for export to the United Kingdom, there will be no difficulty in disposing of them here. Although Indian turpentine derived from *Pinus longifolia* differs from the American and French oils in certain respects (and it is this oil which is produced in commercial quantities), it can be used in place of either; the quality of the oil

now being produced, as a result of the experience gained and the improved distillation methods, is greatly superior to that formerly put on the market, and British varnish-makers who have had the opportunity for trying it on a fair scale are well satisfied with its quality. In fact there is good reason to believe that Indian turpentine would now fetch in this country as good a price as American, which is at present worth 124*s.* per cwt. The prospects of finding a market here for Indian rosin are equally favourable, and it is understood that several thousand tons could at the present time be disposed of at prices up to £56 per ton.

NICKEL INDUSTRY OF CANADA

THE Royal Ontario Nickel Commission, appointed in 1915 to investigate the nickel-ore resources of Ontario and elsewhere and the nickel-mining industry, has recently issued its *Report*, which is an important document, dealing as it does thoroughly and comprehensively with all aspects of nickel production. The Commission consisted of the late G. T. Holloway, Esq., A.R.C.Sc., F.I.C., Vice-President of the Institution of Mining and Metallurgy (*Chairman*); W. G. Miller, Esq., M.A., LL.D., Provincial Geologist, Ontario; McGregor Young, Esq., M.A., Barrister; and T. W. Gibson, Esq., Deputy Minister of Mines, Ontario (*Secretary*). The *Report* deals not merely with the nickel resources and production of Canada, but with those of the world as a whole, and will prove indispensable as a work of reference to all who are interested in any way with the metal nickel, the ores from which it is obtained, the geology and mining of the ore deposits, the metallurgical problems of nickel, and the more general economic questions of taxation and competition.

An article dealing with the occurrence and utilisation of nickel ores was printed recently in this BULLETIN (1916, **14**, 228), and it will therefore be of interest to readers to have a supplementary account giving a summary of some of the more interesting features of the report of the Ontario Nickel Commission.

With reference to the refining of nickel in Ontario, the Commissioners note with gratification that, although at the time they began their work it was asserted by all the companies interested that nickel could not be economically refined in Ontario, there is now an assured prospect of the erection in Ontario of two large plants for the refining of nickel; one by the International Nickel Company of Canada, Ltd., at Port Colborne; and the other by the British America Nickel Corporation, Ltd., probably at Sudbury, if a supply of electric power can be obtained. The output of these refineries, added to the nickel now being produced in the United Kingdom from Ontario matte, will fully meet, if not surpass, the entire requirements of the British Empire.

As to compulsory measures for ensuring that the whole of the nickel output of Ontario should be refined within her borders, the Commissioners are advised that the Provincial Legislature has no power to prohibit export or to impose an export tax directly, and the power of the Province in effect to regulate export by differential taxation in favour of nickel refined within the Province is a matter of grave doubt.

With reference to public ownership of the mines and mining industry of Ontario, the Commissioners state that the expropriation of the deposits and plants of the Sudbury nickel area would probably cost not less than $100,000,000, which sum is approximately equal to the total paid-up capital stock of all the chartered banks in Canada. Among other considerations it is pointed out that the nickel industry is to a considerable extent dependent for its success on the highly-trained technical men who superintend it, and who command salaries far beyond those which are paid in the Government service to the most highly-placed employees. The Commissioners are of opinion that there is no good reason why the State of Ontario should be asked to run the risk involved in the purchase of nickel deposits and plants.

A noteworthy feature of the work of the Commission as regards the utilisation of nickel is the experimental work it undertook in the production of nickel-copper

steel direct from Sudbury ore, and also in the electrolytic refining of nickel.

The Sudbury ore contains from 40 to 45 per cent. of iron which is lost by the present method of treatment; and the possibility of utilising this iron by direct smelting to produce nickel-copper steel has long been recognised, though this would necessitate the loss of the precious metals now obtained as by-products. The importance of this question may be judged from the statement made by the Commissioners that 1,000,000 tons of typical Sudbury waste slag should theoretically yield over 400,000 tons of nickeliferous pig, containing 3,000 tons of nickel and 2,500 tons of copper. In 1916 about 1,500,000 tons of waste slag was produced.

There is, however, a trade prejudice against the use of steel containing copper, although it has been claimed that small amounts of copper are beneficial rather than harmful in steel. To test this question the Commissioners asked Prof. G. A. Guess, of the University of Toronto, to make experiments in the production of nickel-copper steel direct from Sudbury ore, and also to investigate the quality of nickel steels containing copper.

Prof. Guess produced a series of 3½ per cent. copper-nickel steels, with varying ratios of copper to nickel, in order to study their properties. The steels were forged by the John Whitfield Company of Toronto and found to be of good quality. The percentages of nickel varied from 1·8 to 3·43, and the copper from 1·7 to 0·03. In concluding the description of his experiments Prof. Guess states that in his opinion copper may replace a very considerable amount of the nickel in a 3·5 per cent. nickel steel without producing an inferior article.

Under the head of refining processes, the Commissioners remark that there are three processes in use for refining nickel ore of the Sudbury (Ontario) type. These are: (1) the Orford process employed by the Canadian Copper Company, (2) the Mond process and (3) the electrolytic process. For all three processes the production of a matte is essential, and the method of matte production for all three is substantially the same.

As regards the costs of refinement, the enquiries made by the Commissioners have led them to the conclusion that the costs of the three different processes do not differ to such an extent as to give any one of the processes a material advantage over the others in competition. They state further that there is nothing to prevent the Hybinette process of the British America Corporation being operated as cheaply and as efficiently in Ontario as in Norway. On the contrary, it is expected that the costs at Sudbury will be less than they have been in Norway, owing to the larger scale of the operations in Ontario.

The Commissioners call attention to the considerable losses involved in the mining, smelting and refining of the nickel ore and matte. On this subject they agree with the companies that there is no reason to anticipate much further saving on smelting operations, and that the losses in the smelting of nickel-copper ores are always likely to be greater than those inherent in ordinary copper smelting, with which the treatment of the Sudbury ore is fairly comparable. The losses of the Canadian Copper Company in the slags from the smelting at Copper Cliff amounted in the year ending March 31, 1916, to about 8·9 per cent. of the total nickel, and about 9·6 per cent. of the total copper. The losses on the roast heaps through leaching are not definitely known, but they have been estimated by the Canadian Copper Company at about 1½ per cent. of the total copper and nickel.

It is expected that the losses in mining will be gradually reduced as the grade of ore mined becomes lower. There is good reason to expect that flotation processes will be applied to Sudbury ores in the future, and this will result in a fuller recovery of nickel from any given mine than is the case at present. Much low-grade ore that could be treated by the flotation process is now left in the mine or stored in dumps.

The Commissioners point out that Ontario is fortunate in possessing abundance of water power, and in this respect a comparison is made with Norway, where conditions as regards climate and the absence of coal-fields are closely similar to those prevailing in Ontario.

Every important mining camp in Ontario is supplied with hydro-electric power, and the cost of this power is only about one-third the cost of power obtained from coal or wood. The following is an estimate of the available water power in Ontario, and the amount of power so far developed as given by H. G. Acres, Hydraulic Engineer of the Hydro-Electric Commission of Ontario:

Division.	Potential H.P.	Developed H.P.
Ottawa River and its tributaries . .	688,000	71,000
Great Lakes tributaries	446,000	137,000
Hudson Bay Slope	250,000	22,000
James Bay Slope	1,500,000	30,000
International Boundary Waters . .	2,045,000	462,000
Total	4,929,000	722,000

In an appendix to the *Report*, H. G. Acres deals with the hydro-electric developments and possibilities of the Province in relation to the mining and refining industries, and it is shown that as regards the cost of electric current Ontario compares favourably with various parts of the United States.

The special bearing of this abundant and cheap supply of water power on the nickel industry consists not only in the use of electric energy generated therefrom in the operation of mines and smelters, but also in the fact that it enables the electrolytic method of refining nickel to be employed under advantageous conditions as to cost. The Hybinette electrolytic process is the one adopted by the British America Nickel Corporation for the refinery it is to erect at Murray Mine, Sudbury.

The Commissioners take a very optimistic view on the question of competition with foreign producers, but they point out that, while competition is not to be feared, it would be futile to try to shut off the supply of nickel from any of the great nations, since nearly every important country has supplies of nickel ore which can be worked if the demand is great and the price consequently high.

The proved reserves of ore in the Sudbury area are conservatively estimated at 70,000,000 tons; the probable total reserves are much in excess of this, and may be as much as 150,000,000 tons. The International Nickel Company's published estimate of their ore reserves

is 57,000,000 tons, and this is for three mines only. Although the Sudbury deposits have been worked for twenty-nine years, there is vastly more proved ore in the district to-day than there was five years ago.

An estimation of the ore reserves of New Caledonia, which is Ontario's only serious rival in nickel production, is considered impossible owing to their uncertain character, but it is probably fair to say that New Caledonia possesses at least as much high-grade ore as she has already mined in the forty years of her existence as a producer. This would give a total of say 160,000 tons of metal, which would represent about four years' output from Sudbury at the present rate of production.

When the Sudbury industry began, practically the whole of the world's demand for nickel was supplied from New Caledonia. In 1900 about 65 per cent. of the world's nickel came from New Caledonia and about 35 per cent. from Canada. The world's output has increased fivefold since that time, and Ontario now produces over 80 per cent. of the whole. The production of Ontario in the last fifteen years has increased ninefold; the production of New Caledonia by less than 20 per cent.

The chief factor that has enabled Sudbury to outdistance its only serious rival is the difference in the size of the ore bodies in the two countries. The principal Ontario deposits contain ore that is measured in tonnages of millions, while those of New Caledonia are reckoned in a few hundreds of thousands. The greatest of her deposits contained about 600,000 tons; few reached 250,000 tons.

The essence of the matter so far as competition with New Caledonia in the open market is concerned is the cost of the refined nickel produced from its ores. So long as the price of nickel remains about the same as it has been during recent years, New Caledonia will have an important industry, which will probably expand to some extent, owing especially to the activities of the newer of the two companies that are shipping ore and smelting on the island; but there is no good reason for believing that the competition with Ontario will become any stronger than it has been in the past.

While therefore it is true that Ontario has no monopoly, it possesses many advantages over all competitors, even under the present conditions of the market as to prices and trade connections. In any keen competition as to prices it is doubtful whether any other locality at present known could compete with Ontario. It may be doubted further whether anything but an arrangement of the market between the great interests can prevent the complete domination of the world's trade by the nickel industry of Ontario if the latter makes the best use of its exceptional resources.

The statistics of production of nickel and copper at Sudbury are very interesting as showing the rapid growth and importance of the nickel industry. The figures show that for the first nine or ten years, commencing with the year 1887, the growth of production at the Sudbury mines was slow, competition from New Caledonia strong, and the demand small. The production of ore in 1897 was only 93,155 short tons.

Beginning with 1898, there was a steady though not rapid increase, but production fell in the years 1902 and 1903. In 1904 an improvement set in, and from that time, down to the present, there has been a fairly steady and very large increase in production. The output of ore from 1896 to 1900 inclusive was 82 per cent. in excess of that mined during the previous five years; 1901–5 shows an increase over 1896–1900 of 65·8 per cent.; 1906–10 over 1901–5 of 78·6 per cent.; and 1911–15 over 1906–10 of 101·9 per cent. The increase in 1916 over 1915 was 18 per cent. The quantity of ore raised and the estimated nickel and copper content of the matte shipped to the refineries during the last five years, and the total figures for the years 1887–1916 inclusive, are shown in the following table:

	Ore. *Short tons.*	Nickel. *Short tons.*	Copper. *Short tons.*
1912	737,656	22,421	11,116
1913	784,697	24,838	12,928
1914	1,000,364	22,759	14,448
1915	1,325,973	34,039	19,608
1916	1,572,804	41,299	22,430
Total, 1887–1916	10,866,392	284,838	175,003

In summarising their conclusions the Commissioners express the following opinions:

The nickel-ore deposits of Ontario are much more extensive and offer better facilities for the production of nickel at low cost than do those of any other country; and Ontario nickel has little to fear from competition.

Any of the processes now in use for refining nickel could be successfully worked in Ontario, and conditions and facilities are at least as good in this Province as in any other part of Canada.

In view of the fact that practically no chemicals are required, that there is much more complete saving of the precious metals, especially platinum and palladium, and that electric power is cheap and abundant, the most satisfactory method of refining in Ontario will be the electrolytic method.

The refining of nickel in Ontario will not only benefit the nickel industry, but will promote the welfare of existing branches of the chemical and metallurgical industries and lead to the introduction of others.

The present system of mining taxation in Ontario is just and equitable and in the public interest, and is the best system for the Province. Any question of change is rather one of rate than of principle.

The present rate of profit tax, 3 per cent., has been in force for ten years. If in view of the increased revenue which will be required it should be necessary to call upon the mining industry for a larger contribution, the Commissioners are of opinion that the rate on the net profits should not exceed 5 per cent.

The Commissioners' *Report* is well illustrated. It includes a useful bibliography, and a voluminous appendix, comprising the valuable evidence of the witnesses who appeared before the Commission, together with written material submitted to it by various experts and companies connected with the nickel industry. The chapter describing the nickel deposits of the world (pp. 95–286) has been reprinted and issued separately as *Publication* No. 497, by order of the Legislative Assembly of Ontario (Toronto: The King's Printer, 1917).

NOTES

Imperial Institute Handbooks to the Commercial Resources of the Tropics.—A new volume of this series of Handbooks entitled *Cotton and Other Vegetable Fibres: their Production and Utilisation*, by Ernest Goulding, D.Sc. (Lond.), F.I.C., of the Scientific and Technical Department of the Imperial Institute, has been issued recently.

The new volume, which consists of 231 octavo pages, is illustrated by photographs and is published by Mr. John Murray, Albemarle Street, W.1, price 6s. net.

The introductory chapter deals briefly with the classification of fibres and methods of investigation. Cotton, as the most important of vegetable fibres, naturally receives greatest consideration. Different sections are devoted to a description of the cotton plant; an account of the structure and composition of the fibre; the methods of cultivation, including a review of the cultural systems adopted in the United States and Egypt; the diseases and pests of the crop; and the preparation of cotton for the market. Particulars are given as to the production and varieties of cotton in the chief cotton-growing countries of the world, including the United States, Egypt, India, Peru, Brazil, Mexico, Asiatic Russia, China and Japan, and special reference is made to the cotton-growing industry in British West Africa, whilst other parts of the British Empire where cotton is cultivated, such as the Sudan and East Africa, are also dealt with.

In the case of the more important textile fibres, other than cotton, such as flax, hemp, ramie, jute, Manila hemp, Sisal hemp, Mauritius hemp, New Zealand hemp, etc., detailed information is provided as to methods of cultivating the crop and preparing the fibre, and an account is given of their production in the principal countries of the world together with statistics of trade and market prices. The lesser-known textile fibres, such as sunn hemp, those suitable as substitutes for jute, banana and plantain fibres, bowstring hemp (Sansevieria fibres) and oil palm fibre are dealt with more briefly, whilst the concluding chapter deals with various miscellaneous fibres, including coir, piassava, palmyra, kitool, Mexican fibre, Italian and Mexican whisks, flosses or silk-cottons, vegetable curled hair, raffia or bass, and paper-making materials.

The French Oil-seed Industry.—The Institut Coloniale de Marseille has recently appointed two Committees to deal with the sources of the raw materials used in the

oil-seed and cereal industries of Marseilles. The scope of the enquiries will be similar to that conducted by the special committee appointed by the British Colonial Office in 1915 to investigate West African Oil Seeds (cf. this BULLETIN, 1916, **14**, 277). According to M. Emile Baillaud (*L'Expansion Coloniale*, 1917, No. 86) the French oil-seed crushers did not before the war take up new oil seeds, but, as in the case of British manufacturers, have largely left the initiative in such matters to Germany. As a consequence they have not fully utilised and developed sources of supply in their own colonies, and one of the chief objects of the committee on oil seeds will be to ascertain how this state of affairs can be remedied.

The principal questions to be considered by the committee are: (1) the extension of the production of oil seeds (ground nuts, palm kernels, copra, olives, shea nuts, castor seed, sesame, etc.) in the French Colonies; (2) the transport of oil seeds; (3) the utilisation and marketing of oil-cakes; (4) the study of the oil-seed industries in other countries.

The only oil seeds at present being exported in large quantities from the French Colonies are ground nuts, palm kernels and copra. The total exports of these products in 1913 and the amounts sent to France, the United Kingdom and Germany, are shown in the following table, compiled from the annual volumes of statistics published by the French Colonial Office.

Oil Seed.	Chief Producing Countries.	Total Exports.	France.	United Kingdom.	Germany.
		Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Ground nuts .	Senegal, Upper Senegal and Niger, and French Guinea . .	218,723	177,934	103	25,641
Palm kernels .	Dahomey, Ivory Coast, and French Guinea	40,068	4,120	1,548	35,132
Copra . .	French Oceania, Indo-China, and New Caledonia . . .	17,683	10,571	1,266	nil.

It will be seen that in the case of ground nuts and copra, most of the output was sent to France, that country being by far the most important consumer of ground nuts in Europe and second only to Germany as regards its consumption of copra. In the case of palm kernels, however, most of the exports went to Germany, and in this respect the French colonies were in the same position as the British West African possessions (cf. this BULLETIN, 1914, **12**, 458).

Among oil seeds exported in smaller quantities from

the French Colonies are sesame seed (about 2,000 tons, mainly from Indo-China and French Guinea), shea nuts (about 450 tons from Upper Senegal and Niger) and cotton seed (about 500 tons from Dahomey and New Caledonia).

There is a possibility of an extension in the production of all the oil seeds referred to above in the French Colonies; Indo-China in particular offers good prospects for an increase in its output not only of copra and sesame, but of other oil seeds. M. Brenier, in two recently published papers on the oil-seed resources of Indo-China (*Comptes Rendus des Séances de l'Academie d'Agriculture de France*, 1917, **3**, 185, and *Bulletin de l'Office Coloniale*, 1917, **10**, 31), states that the crops already being grown there and whose cultivation could be extended include copra, sesame, cotton, soy beans, castor seed, and ground nuts. Other oil-yielding plants of the colony are Chinese tallow tree (*Stillingia sebifera*), Japan wax tree or wild varnish (*Rhus succedanea*), *Calophyllum Inophyllum*, *Bassia* sp., *Camellia drupifera* and *Garcinia tonkinensis*, all of which could supply the French oil-seed market in greater or smaller amounts, whilst it is stated that the Chinese wood-oil tree, known locally as "abrasin," is well adapted to village plantations in Central Tonkin.

The Oil-Seed Committee of the Marseilles Colonial Institute has recently issued two *Bulletins*. The first contains a translation of the *Report* of the British West Africa Oil-Seeds Committee, and the second a translation of the evidence submitted to that Committee on the subject of ground nuts. *Bulletin No.* 2 also contains (1) an article, by M. E. Mathon, in which he adduces strong arguments in favour of the decortication of ground nuts in Senegal, (2) an outline of the procedure to be adopted in the investigation and encouragement of the trade in the more important oils and oil-seeds and (3) notes on the feeding value of certain oil-cakes, including an abstract of the information given in the Imperial Institute monograph, *Oil Seeds and Feeding Cakes*, published by Mr. John Murray in 1915.

The recommendation that ground nuts should be decorticated in West Africa is of particular interest at the present time when the necessity for large supplies of oil seeds is great and economy of shipping is essential, and is of special interest in connection with the Indian trade in ground nuts. According to M. Mathon, Senegal alone produces 250,000–300,000 metric tons of ground nuts annually. Although storage space for ground nuts in Senegal has been increased greatly during the last

two years, there is at present accommodation for only about 100,000 metric tons, and it is necessary, therefore, in order to avoid deterioration, to ship the bulk of the output before the commencement of the rainy season, *i.e.* between January or February and May or June according to locality. At the present time shortage of shipping renders the transport of such quantities of nuts impossible, but the problem could be simplified if only the kernels were shipped.

As landed in Europe, 1 ton of ground nuts in shell only represents 0·7 ton of kernels, the remainder consisting of useless shell and dirt; further, the waste of space caused by shipping nuts in shell is considerable, as 1 ton of nuts in the shell occupy the same cargo-space as 1·6 tons of kernels. It is estimated that the saving of shipping space obtained by exporting the kernels instead of the undecorticated nuts would amount to 56 per cent.

As is well known, decorticated ground nuts have been shipped from India for many years past. These generally reach Europe in poor condition, partly owing to faulty methods of decortication causing damage to the kernels, and partly to the long voyage through hot regions. For the last few years decorticated ground nuts have been shipped from Northern Nigeria, and in spite of the rail journey to the coast of about 700 miles and a sea-voyage of about three weeks, these reach Europe in good condition, and can be used for the production of edible oil of good quality. There is a good ground therefore for the assumption that ground nuts properly decorticated in Senegal should reach Europe in excellent condition, as the average distance of transport by rail would only be about 120 to 200 miles, followed by a sea-voyage of ten to fourteen days mostly in temperate regions. The chief points against the decortication of the nuts in the country of origin are the demand for oil of high quality prepared from nuts shipped in the shell, the difficulty at present experienced of obtaining machines for decorticating the nuts and sacks for shipping the kernels, and the interference with the native custom of selling nuts in the shell.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

FOODSTUFFS

Coffee.—In Porto Rico the general practice in transplanting coffee is to pull or dig the young plant out of the ground without exercising any care to prevent the breaking of the roots. As a result, growth is greatly retarded and, in some cases, the young trees are killed. In view of the prevalence of this unsatisfactory method, trials have been made of the effects of different ways of transplanting and the results have been published as *Bulletin No. 22, Porto Rico Agric. Expt. Stat.* This work has led to the following conclusions. The mature seed may be planted immediately after pulping, or may be washed and kept spread out in a shady place for not more than three or four months before sowing. If the seed is allowed to become too dry, its vitality is affected. The seed should be sown at a depth of about ¼ in. and the seedlings should be not less than 8 in. apart. During growth the seedlings should neither be too densely shaded nor exposed too much to the sunlight. Transplanting may be carried out in the second rainy season after planting. Plants growing in a heavy clay soil should be removed with the roots still embedded in the soil. This can be effected by cutting out a block of the soil by means of a spade. The trees, each with the roots enclosed in such a block of earth, are replanted in holes prepared in advance. They should be so set that the root collar is just below the surface, and the earth should be well compacted round the plant to prevent it from settling much below this level.

Sugar.—In the *Journal of the Board of Commissioners of Agriculture, Porto Rico* (1917, 1, 17), an account is given by John R. Johnston, formerly pathologist of the Insular Experiment Station, of the history and cause of the rind disease of sugar cane. The study of this disease was undertaken as, chiefly owing to inaccurate and incomplete observations, the literature of the subject is very confused

as to the real nature of the fungus and the disease caused by it. The disease is characterised by the appearance of numerous black pustules breaking through the rind of the cane. These pustules may appear merely as numerous tiny black threads or sometimes as a coherent mass of spores in the form of a stalk, varying in shape and up to 1–2 mm. in length. When the pustules appear, the tissues of the cane itself are already discoloured and diseased. Another symptom of the disease is the drying up of the leaves. In Porto Rico infection with the rind fungus seems to be always preceded by a reduction of the vitality of the cane by some other condition, such as wounds, root disease, drought or floods. Field investigations have shown that the fungus is capable of causing great damage to mature canes.

The rind fungus, *Melanconium sacchari*, occurs in the Southern United States, the West Indies, British Guiana, Natal, Mauritius, India, Australia, Hawaii, and probably in Java. The life-history of the fungus is very simple, consisting only of the vegetative part producing spores of but one form which, in turn, reproduce the plant. The only methods of controlling rind disease are to grow hardy varieties of cane, to adopt means of reducing attack of the moth-borer, and to crush the cane before it is over-ripe.

Wheat.—In the *Rep. Agric. Res. Inst. and Coll., Pusa*, 1915–16, an account is given of the progress of the Indian wheat investigations. In the United Provinces a decided advance has been made in the replacement of the local varieties by that known as Pusa 12. This variety has been found capable of withstanding drought, and is therefore likely to replace the best local kinds, such as Muzaffarnagar, in the canal tracts where recurrent shortages of water are experienced. The wheat is superior in quality to the native varieties, and also gives larger yields. It is estimated that the substitution of the country wheats by Pusa 12 would result in an increased profit of £1 per acre or £7,000,000 per annum for the whole of the United Provinces.

Another variety, known as Pusa 4, has given good results in areas, such as Bundelkhand, some of the Central India States, the southern portions of the Bombay Presidency and parts of Bihar, in which a wheat is required which can ripen quickly with a small supply of moisture and can also resist the early rusts. This variety is being well taken up by the cultivators, and the demand for seed is increasing. A complete milling and baking test of this wheat has been carried out at the Hooghly Flour

Mills, Calcutta, with very favourable results. Pusa 4 has also been introduced into New South Wales, and has proved superior to any of the other new varieties grown in that country. Supplies of Pusa 12 and Pusa 4, sufficient for complete milling tests, have been shipped to the United Kingdom.

The experimental work conducted at Pusa has led to the production of four series of very promising new crosses, in connection with which an effort is being made to evolve types combining rust-resistance, standing-power, quality and yield. From these forms it is hoped to obtain a set of wheats which will replace all those now under cultivation in India. Much remains to be done, however, in improving wheat cultivation by the control of irrigation water, the proper management of alluvial soils, and the practice of green-manuring. When sufficient progress has been made in these directions, the country will be in a position to benefit by the introduction of the new varieties of wheat now being developed at Pusa.

Oils and Oil Seeds

Coconuts.—The intentional destruction of coconut palms without official sanction is forbidden in Negri Sembilan by an enactment passed in June 1917 (*F.M.S. Govt. Gazette*, 1917, **9**, 1101).

Cod-liver Oil.—Large quantities of Norwegian cod-liver oil have been sold to Germany during the war, and, in consequence of the shortage of supplies, prices of Newfoundland oil have risen considerably. Advantage is being taken of this situation in Newfoundland, and every effort is being made to produce oil equal in quality to the best produced in Norway. According to an Act passed in May 1916, all refiners of cod-liver oil in Newfoundland must be licensed and no refined cod-liver oil may be exported unless it has been first officially inspected and branded (*Legislative Acts, Newfoundland*, 1916, p. 193). The two brands authorised by Rules published in the *Royal Gazette, Newfoundland*, May 1, 1917, are as follows: (*a*) signifying non-freezing cod-liver oil for human consumption, and (*b*) signifying refined cod-liver oil for human consumption. No package, other than a new oak barrel, made specially for refined cod-liver oil, a tin-lined barrel, or a butter oil cask, may be used to contain refined cod-liver oil. Inspectors appointed under the Act visit all factories and instruct manufacturers in the most approved methods of manufacture. It is stated in the *Annual Rep. Dept. of Marine and Fisheries, Newfoundland*,

1916 (Appendix, p. 27), that the new Act worked admirably during the year and that the manufacturers were anxious and willing to learn the method of producing the finest medicinal oil. The exports of refined oil in 1915–16 amounted to 142,637 gallons, valued at £53,034 or 7s. 5*d.* per gallon, as compared with 47,170 gallons valued at £7,496 or 3s. 2*d.* per gallon in the preceding year (*loc. cit.*, p. 11). Most of the oil produced in Newfoundland, however, is still shipped in the crude state, and in 1915–16 1,313,280 gallons of cod oil, valued at £142,153, were exported, the amount in 1914–15 being 1,230,040 gallons, of value £90,564.

It may be mentioned that the whole question of the quality of Newfoundland cod-liver oil is at present being enquired into at the Imperial Institute.

Ground Nuts.—Although records of the total area under ground nuts in the United Provinces are not available, the cultivation of ground nuts is spreading (*Rept. Dept. Agric. U.P.*, 1915–16, p. 8), chiefly in the neighbourhood of large towns, where the nuts are mainly used for food. The suitability of this crop for cultivation on poor, light soil has resulted in much light land being broken up, especially near Lucknow. Average yields of about 2,057 lb. per acre are obtained, and at the local price of about 9*s.* per cwt. the crop is a profitable one.

Linseed.—The varieties of linseed grown in India belong to distinct types, those grown on the black soils of Central India being deep-rooted plants of erect form and bearing large seed, while those of the alluvial soils of Bihar and the United Provinces are shallow-rooted and bear small seed (*Agric. Journ., India*, Special Indian Science Congress Number, 1917, p. 19). A study of the varieties of Indian linseed has been commenced on lines similar to those followed in the case of safflower and rape (cf. this BULLETIN, 1916, **14**, 474), and attempts are being made to produce by crossing a large-seeded variety of surface-rooting habit suitable for growth on alluvial soil (*Rep. Agric. Research Inst., Pusa*, 1915–16, p. 32).

Perilla Seed.—This seed is cultivated in China and Manchuria and to a less extent in Japan; it yields an oil with strong drying properties (cf. this BULLETIN, 1912, **10**, 303). Large quantities of the seed are shipped from Dairen (Dalny) and come from districts adjacent to the South Manchuria railway and also along the Chinese Eastern and Chinese railways, the Taolu district furnishing almost two-thirds of the total quantity arriving at Dairen

(*U.S. Commerce Reports*, 1917, No. 205, p. 830). In 1915 4,430 tons of seed were exported from Dairen, the whole export being sent to Japan, where the seed was selling at £13 to £14 per ton f.o.b. Yokohama (*U.S. Commerce Repts.* 1917, No. 105, p. 474). In Japan the annual crop amounts to about 600 tons, but the imports of seed are fairly large, as is indicated above; in addition to the seed imported from Dairen there is a small import from China (*loc. cit.*, p. 474). The quantities of perilla-seed oil produced in Japan were 1,283,662 (U.S.) gallons, valued at £144,000, and 930,436 gallons, valued at £101,000, in 1912 and 1913 respectively. Statistics of the exports of perilla-seed oil from Japan are not available.

Miscellaneous.—The seed of bitter oranges contains 37·5 per cent. of oil suitable for use in the manufacture of soap. Considerable quantities of seed are said to be available in normal times as a by-product in the manufacture of marmalade (*Analyst*, 1917, **42**, 271).

Rubber

Hevea.—In 1915 the area under rubber in British North Borneo was 29,827 acres or over 30,000 acres if plantations of less than 100 acres are included. Of this area the trees on 9,806 acres were being fully tapped and 570,000 trees were being tapped on areas not yet under full tapping. During 1915 1,050 tons of rubber were exported (*Rep. on Agric., State of North Borneo*, 1915). The average yield from seven estates with a total area of 4,300 acres was nearly 300 lb. per acre. Many estates are discontinuing the practice of clean-weeding, and encourage the growth of "Bermuda grass" (*Cynodon Dactylon*), which forms a fairly effective cover crop and does not grow to an inconvenient height or tend to get out of hand. Efforts are being made to find a satisfactory leguminous cover-crop of low-growing habit; of those under trial at the new experimental garden at Jesselton, *Dolichos Hosei* (Sarawak bean), and *Centrosema Plumieri* appear to be the most suitable for hilly land.

A series of illustrated articles dealing with the production and preparation of raw rubber is now appearing in the *Engineer*. The first of these articles (*Engineer*, 1917, **124**, 399) mentions the more important trees used as sources of rubber, and describes briefly the methods of tapping and the preparation of Brazilian and plantation Para rubber.

Miscellaneous.—The exports of jelutong from the Dutch East Indies amounted to 9,564 tons in 1916,

compared with about 7,800 tons in the two previous years (*Ned.-Ind. Rubbertijdschrift*, 1917, 2, 1).

It has long been known that a kind of "gutta" can be obtained from the trunks of the Shea butter tree (*Butyrospermum Parkii*). According to the *Nigeria Gazette* (Suppl. No. 38, Aug. 2, 1917) a trade in this "gutta" has sprung up during the last two years in the Bornu province of Nigeria. Tapping of the trees is performed by chipping out small pieces of bark with a narrow native axe; the latex which exudes is scraped off the bark the next day and freed from bark and dirt by boiling. It is recommended that trees under 30 in. in girth should not be tapped, and that natives should be encouraged to collect the nuts for use as a source of fat (shea butter). The "gutta" sells locally at about 4*d*. per lb.

Fibres

Jute.—An interesting paper by Mr. R. S. Finlow, B.Sc., Fibre Expert to the Government of Bengal, on the improvement of the jute crop by pure line selection has been published in the *Agric. Journ. India* (1917, **12**, 283). Work on the improvement of Indian jute has been in progress for several years with a view to obtaining a type of plant of high yielding power and furnishing a fibre of maximum strength and durability. Hitherto no single plant has been found which combines all these qualities in the highest degree, but some approximation to this ideal has been realised, and it is hoped that the desired result may eventually be obtained by hybridisation. Meanwhile, seed of pure lines has been obtained which give large yields of fibre of excellent quality, and, of these, a race termed Kakya-Bombai has proved the best. During the 1916 season about 12,000 lb. of the seed of this variety were sold, which was a sufficient quantity to plant 1,500 acres.

The climatic conditions of Western Bengal differ greatly from those of Eastern Bengal, especially in respect of the early rainfall which is characteristic of the latter and largely lacking in the former. Sowing time is therefore much later in Western than in Eastern Bengal, and for this reason *Corchorus olitorius* is much more suitable than *C. capsularis*. It has therefore been necessary to undertake a separate scheme of selection for Western Bengal, and seed of pure races of *C. olitorius* is now being produced. With regard to *C. capsularis* it is possible that the same race will not do equally well in all parts of Northern and Eastern Bengal, and field tests are being

carried out with the object of gaining definite information on this point.

Efforts are also being made to effect an improvement of the jute crop by means of a better system of cultivating and manuring (cf. this BULLETIN, 1917, 15, 283). Valuable results have already been obtained in this direction and are being demonstrated to the cultivators by a special staff. The development of this side of the work demands a certain outlay by the cultivator on implements and manures, and assistance in this direction is being afforded by the co-operative credit societies.

Cotton

In the *Annual Report of the British Cotton Growing Association for the year ending 31st December*, 1916, it is pointed out that the grant of £10,000 per annum from Imperial funds expired on March 31st, 1916, but it was subsequently arranged that a grant of £1,000 per annum should be made to the Association, and this expired on March 31st, 1917. When the question of the renewal of this grant came up for consideration, it was felt that as the present crisis had so fully demonstrated the vital need of developing cotton cultivation in the British Empire as rapidly as possible and the situation had become so serious, it was essential that much greater efforts should be made, and that it was therefore necessary that the Government should come to some definite decision with regard to the future of the cotton-growing movement.

The Council of the Association therefore held a conference with representatives of the Lancashire cotton trade in December 1916, at which the following resolutions were passed. (1) That the present situation as to the supply of cotton is most serious, and requires the immediate attention of His Majesty's Government. (2) That it is essential for the future prosperity of this country and also for the welfare of the Colonies that cotton growing should be developed as rapidly as possible in all suitable parts of the Empire. (3) That the authorised irrigation works for the development of the Gezira plain be pushed on with the least possible delay. (4) That immediate steps should be taken to improve the quality and to increase the quantity of Indian cotton. (5) That a departmental or other committee be appointed to consider the best method of continuing and developing the work inaugurated by the British Cotton Growing Association, and that pending a decision on this question the Government should render such financial and other assistance

to the Association as will enable them to carry on their work to the fullest possible extent.

Representations were subsequently made to the Board of Trade, and the Government have now appointed a Committee to enquire into the whole question.

During the year under review there appeared to be no prospect of any appreciable quantity of cotton being produced in the Gold Coast, and the work in the Northern Territories and at Labolabo has therefore been discontinued.

The total amount of cotton purchased in Nigeria in 1916 was 20,032 bales, which is 4,512 bales in excess of the previous highest record of 15,520 bales in 1913. Of this quantity, 10,746 bales were obtained from the Northern Provinces and 9,286 bales from the Southern Provinces.

Great difficulty was experienced with reference to the disposal of the cotton seed produced in West Africa, Uganda and Nyasaland, and in consequence of the lack of shipping facilities many thousand tons of seed, amounting in value to over £200,000, had to be destroyed.

Queensland.—It is stated in the *Queensland Agric. Journ.* (1917, 8, 53) that during 1916 the State ginnery dealt with 29,230 lb. of seed-cotton which yielded 10,066 lb. of prime lint, 880 lb. of second-class lint and 18,284 lb. of seed. The yield of cotton on ginning amounted to 34·4 per cent. The ginned cotton was sold locally at 6·9*d*.–7*d*. per lb., and the seed was purchased by the Department of Agriculture and Stock for redistribution to the farmers for planting in 1917. The growers received a net return of 2·54*d*. per lb. for their seed-cotton, which, at the average yield of 1,000 lb. per acre, was equivalent to £10 11*s*. 8*d*. per acre. After allowing for the cost of cultivating and picking the crop, the net profit amounted to £7 14*s*. 9*d*. per acre. This return is better than that given by any other of the ordinary farm crops of Queensland with the exception of rice, which yields an average net profit of £8 16*s*. 3*d*. per acre.

ECONOMIC MINERALS

Iron Ore.—In monthly *Bulletin Can. Min. Inst.*, No. 65, Sept. 1917, p. 764, W. M. Brewer deals briefly with the lode-mining industry on Vancouver Island, B.C., and refers to magnetic iron ore deposits of the contact metamorphic type. He states that these deposits are of very considerable extent, and are found at several points on the west coast roughly parallel with the coast line, and usually within a few miles from safe deep-water

harbours. The deposits are stated to contain ore that averages nearly 60 per cent. of iron; the phosphorus is considerably below the Bessemer limit, and the sulphur rarely more than 1 per cent. Development work has been done on some of these deposits. No details are given as to extent and available tonnage of ore, but the owners of the claims appear to be hopeful that the deposits will ultimately be worked.

Magnesite.—In the *Summary Rep.*, *Geol. Surv.*, Canada, 1916, p. 48, C. W. Drysdale refers to discoveries of magnesite, made during the course of geological field work in 1915, at several localities in Bridge River district (British Columbia). The magnesite deposits occur in association with serpentinised peridotite of Mesozoic age. One outcrop, measuring 52 ft. wide by 48 ft. long, was found near the south-west end of Liza Lake. The magnesite includes both massive and crystalline varieties, and is in places traversed by numerous veinlets of clear chalcedonic quartz. The magnesite is in part dolomitic. An analysis of a sample free from dolomite gave magnesia 43·42 per cent., lime 0·46, iron oxides 0·81, silica 7·46, and carbon dioxide 47·28 per cent. The locality is over 30 miles from the Pacific Great Eastern Railway at Bridge River crossing on Seton Lake, and it is thought that the deposits could not be worked at a profit under present conditions.

In *Memoir No.* 98, 1917, *Geol. Surv., Canada*, M. E. Wilson deals with the Magnesite Deposits of Grenville District, Argenteuil County, Quebec.

The magnesite occurs associated with dolomite and serpentine, among the metamorphosed rocks of the Grenville series (pre-Cambrian), and appears at the surface in the form of lenticular outcrops piercing the surface clay and sand of the district. The outcrops range up to 1,000 ft. in length and 300 ft. in width.

The magnesite is intimately mixed with dolomite. Where exposed to weathering, the dolomite dissolves away more rapidly than the magnesite, and a pitted surface is developed.

The lenticular structure is due to deformation taking place after the formation of the minerals occurring in the deposits.

Mr. Wilson is of opinion that the magnesite is of metamorphic origin and that it has been formed by the replacement of the limestone of the Grenville series through the agency of solutions rich in magnesia. The probable order of events according to him was as follows: (1) silication of limestone to diopside, and the

formation of phlogopite in places; (2) formation of serpentine in places; (3) replacement of limestone by dolomite; (4) replacement of dolomite by magnesite; and (5) alteration of diopside to serpentine.

The magnesite everywhere includes more or less dolomite; but diamond drilling and other development work have shown that there are extensive masses containing on the average less than 10 per cent. of lime. It is estimated that the deposits contain a total of 686,900 tons of magnesite with less than 12 per cent. of lime; and 482,700 tons of magnesite-dolomite with more than 12 per cent. of lime.

It is pointed out that as the magnesite deposits are generally associated with the rocks of the Grenville series, and as these rocks usually underlie valleys, the most favourable localities for prospecting for magnesite are the valleys, and especially those where limestone and other members of the Grenville series are present. The occurrence of boulders of magnesite in localities where they could not possibly have been derived from the known deposits of the material indicates that there are other undiscovered deposits of magnesite in the district.

Manganese Ore.—In a *Review of the Mining Operations in the State of South Australia during the half-year ended Dec. 31st, 1916* (No. 25), the Government Geologist and Assistant Government Geologist give an account of the manganese ore deposits of the Pernatty Lagoon. The main group of leases and claims is situated about 4 miles north-east from the "71-mile" or Woocalla, on the Port Augusta to Kalgoorlie railway.

The dominant rock formation of this area is a quartzite of supposed Ordovician age. Superposed on this is a much younger dolomite formation of more doubtful age.

The manganese ore deposits appear to take the form of extensive pockets in the dolomite and overlying soil. Some development has taken place, and the pits in the vicinity of the main open cut do not show the boundaries of the deposit. Analyses of twelve samples show percentages of metallic manganese ranging from about 45 to 56, and percentages of peroxide (MnO_2) ranging from about 65 to 89. In eight of the samples the percentage of phosphorus is less than 0·01, the highest recorded in the twelve samples referred to is 0·09. The sulphur percentage ranges from 0·09 to 0·58.

A considerable amount of manganiferous iron ore is present in the deposits, and a sample of this gave 27·67

per cent. of manganese, 34·04 of iron, 0·15 of phosphorus, and 0·13 of sulphur.

In practically all the deposits so far opened a proportion of overburden has had to be removed; this overburden averages, as a rule, less than 2 ft. in thickness, and only exceptionally attains a depth of 4 ft. In mining the manganese it is estimated that from one to two tons of waste is removed per ton of good ore. The proportion is high, owing to the high-grade product required. If the manganiferous iron ore could be sold there would be less waste.

No estimates of quantities or relative amounts of the different grades available can be given at present; but a feature of special interest is the presence in the deposits of material containing over 80 per cent. of peroxide, which, on account of its utility for chemical purposes, is more valuable than the ordinary metallurgical grades.

In a *Report* on "The Manganese Deposits in the South-West Districts of the Cape Province" (Dept. Mines and Industries, Union of South Africa, 1917), A. B. Welsh gives an account of deposits of manganese ore at Hout's Bay, Constantia Nek, Kogel Bay (in False Bay), Botha's Halt near Worcester, Du Toit's Kloof near Wellington, French Hoek and Caledon. In his summary of the results, the Deputy Inspector of Mines points out that the Cape ores are characterised by a comparatively low percentage of manganese and a rather high percentage of phosphorus. The quantities of ore available are generally not large, the market for them is restricted, their average value is only about 30*s*. per ton, and the costs of mining and transport are heavy.

The exceptional case as regards mining and sorting charges is the deposit at Caledon, which on that account is the most interesting, and the most likely to be exploited.

Unlike the other deposits, which are referred to as "lodes," the Caledon deposit occupies a kopje roughly circular in shape, with hot springs at the centre. Nearly the whole of the kopje consists of manganese ore. In many places there is little or no overburden, and the ore could be worked by open-quarrying. The deposit covers an area of roughly 200 by 300 yards. On the top of the hill there are shafts and workings about 20 ft. deep and still in ore. The deposit thins out and becomes more siliceous as the outer margin of the kopje is approached.

Assuming an average thickness of 10 ft., the available tonnage is estimated at about 500,000 tons. A sample of the best ore showed on analysis 37·87 per cent. of

manganese, 16·3 of iron, 0·014 of sulphur, 0·378 of phosphorus and 6·55 of silica. An average sample was found to contain 25 per cent. of manganese and 30 per cent. of iron. As difficulties standing in the way of exploitation, it is pointed out that a sanatorium and baths have been built on the deposit, and there is a possibility that mining would interfere with the working of the springs; whilst as regards transport facilities the locality is 2 miles by road from Caledon station, which is 87 miles from Cape Town.

Molybdenite.—In an account of the treatment of molybdenite at Orillia, Ontario (*Monthly Bulletin, Can. Min. Inst.*, No. 62, June 1917, p. 506), E. P. Grant states that during 1916 the International Molybdenite Company treated at the new concentrator at Renfrew, and at the old plant, a total of 2,350 tons of ore containing approximately 60,000 lb. of molybdenite (MoS_2). This ore was obtained from properties in Ontario, Quebec and British Columbia. The ores varied according to locality, some containing iron sulphides in large amount, and some being very micaceous. The British Columbian ores were purer than those of Ontario and Quebec, but the flakes much smaller.

Ore containing large flakes yields a fairly good concentrate by screen adjustment, and the concentrate thus obtained from the crushed product is usually taken to the sampling rolls to be cleaned, whilst the undersize goes to the flotation department, which contains nine flotation machines.

The flotation product ranges from 60 to 70 per cent. of molybdenite (MoS_2). Experience has shown that with an average ore it is uneconomical to produce a 90 per cent. concentrate.

The products of the company's refinery at Orillia are ferro-molybdenum, molybdic acid and ammonium molybdate. The company's production of these materials during the year 1916 had a value of nearly £23,000. At the present time the rate of production is much higher, being valued at over £100,000 per annum, and is increasing.

It is stated that this company is the only one in the world that mines and purchases molybdenite ores, operates its own concentrator, uses its own developed process of concentration, refines all the products from its concentrator, and at the same time produces chemically pure reagents.

Steatite.—In *Mem. Geol. Surv., India* (1917, **45**, 125), A. M. Heron gives an account of the geology of north-

eastern Rajputána and adjacent districts, and refers to an occurrence of steatite at Dogetha (Dagota), 2½ miles N.E. of Raialo in Jaipur territory. The deposit occurs in one of the highly ferruginous portions of the Raialo limestone of the Delhi system. The steatite is excavated in an open cutting over a width of about 30 yards and a length of 50 or 60 yards. The steatite is milky-white or faintly tinged with green. The cost of quarrying is about a rupee per six or seven maunds (= 1s. 4d. per 4–5 cwts.), and transport to Dosa railway station is 2 annas per maund (= 2*d.* per 82 lb.) on pack bullocks. From Dosa the steatite is sent by rail, chiefly to Amritsar, and some to Cawnpore. It appears to be used for finishing cloth, and as an adulterant of soap and flour. One of the chief uses of steatite in India is as a polishing and glazing agent in rice-milling.

NOTICES OF RECENT LITERATURE

THE PRESERVATION OF WOOD: A descriptive treatise on the processes and on the mechanical appliances used for the preservation of wood. By A. J. Wallis-Tayler, A.M.I.C.E. Pp. xix + 344, Demy 8vo. (London: William Rider & Son, Ltd., n.d.) Price 10*s.* 6*d.* net; post free, United Kingdom 11*s.*, abroad 11*s.* 2*d.*

This book provides an account of the various processes which have been devised to increase the durability of timber used for industrial purposes. It appears at an opportune moment, for as a result of the enormous consumption and inevitable waste of valuable timber occasioned by the war, it is not improbable that the price of this essential commodity will be enhanced for many years to come; and it will be more than ever a matter of importance to users of timber to avail themselves of practical means of prolonging the life of the material employed by them. The increasing need for efficient means of preservation has been widely recognised in recent years, and the question was already engaging serious attention before the war. It is estimated that in the United States alone an annual saving of upwards of £14,000,000 might be effected if all railway-sleepers, mine-props, piling, posts, structural timber and shingles capable of being so dealt with were subjected to appropriate preservative treatment before use. Further, by special treatment the durability of the cheaper and inferior qualities of timber may be improved, often enabling these woods to be used for purposes for which without

special treatment they are unsatisfactory. It would appear, therefore, that the widespread adoption of rational methods should furnish a not unimportant factor in regulating the increasing cost of timber and conserving existing supplies of the more valuable kinds.

The author has brought together a large amount of information regarding the methods at present in use for preserving and seasoning wood and for rendering it fire-resistant. The introduction provides an interesting summary of the history of wood preservation by means of antiseptics or germicides from 1657 down to the latter half of the nineteenth century, and there are chapters on the destruction of wood by decay and insect attack, and on seasoning and drying. The bulk of the work is concerned with a technical description of the leading systems of preservation. A useful chapter on the preservative treatment of wood quotes extensively from the work of Professor Bailey (Harvard School of Forestry) dealing with the fundamental factors controlling the penetration of woody tissues by preservatives, and is followed by an account of the open tank and pressure systems of preservation. The principal processes and the agents employed therein are then described, and there is a chapter on the cost of preservative treatments.

In other sections of the book the author would appear to be less at home in his subject. The practical man will not be greatly assisted by the statement that "The teredo navalis is one of the acephalous mollusca belonging to the class *lamellibranchiata* of the order conchifera, and of the family of the pholadariæ"; and will be misled in reading that "The latter [dry or sap-rot] . . . occurs in confined places, where the gases evolved, finding it impossible to escape, enter into the new combinations and produce fungi. . . ."

The book is illustrated by a large number of photographs, plans and diagrams, and is provided with an appendix containing formulæ, tables and memoranda likely to be useful to those interested in wood preservation. In a future edition, the botanical names given in the table of principal woods should be revised.

British Grasses and their Employment in Agriculture. By S. F. Armstrong, F.L.S., Univ. Dipl. Agric. (Cantab.). Pp. vii + 199, Demy 8vo. (Cambridge: at the University Press, 1917.) Price 6*s.* net; post free, United Kingdom and abroad 6*s.* 5*d.*

With the reduction of permanent grass land which the circumstances of the war have forced upon the agri-

culturists of this country, the question of the most efficient use of the remaining pasture becomes one of first-class importance if the numbers of live stock are to be maintained. While much of the pasture of this country is justly famous for its quality, a large proportion, estimated at fully one-fifth the total area of grass-land, is weed-covered to a degree that seriously depreciates its value, and to that extent the excellent qualities of many of our native grasses fail to be realised. The appearance of this book is therefore most welcome. It has been written primarily for the agricultural student, but it should prove of value to the far larger class of practical farmers, seed merchants and others directly concerned with the formation and maintenance of pasture. The author has divided his subject into two parts. The first (Botanical Section) deals with the morphology and general biology of grasses, and gives an account of the distribution of the British species together with classifications based upon their vegetative and floral characters respectively. The greater part of this section comprises a well-illustrated chapter affording botanical descriptions of our native grasses arranged in alphabetical order, special attention being given to those species which are more abundant or of greatest economic importance. Emphasis has been laid upon those features which are of significance to the student of agriculture, and usually inadequately dealt with in scientific floras. In the description of the rare and small British grass *Cynodon Dactylon* it would have been of interest to refer to the physical stature reached by this plant in other latitudes, where, as in India, the West Indies and elsewhere in the tropics it forms a most important fodder grass.

The section also includes an illustrated key to grass "seeds."

Part II (Agricultural Section) is concerned with the practical aspect of the question, the agricultural value of different grasses, the valuation and purchase of seed, specification and compounding of grass seed-mixtures, and the general treatment of grass land being the subjects considered. The author has dealt with the formation of permanent grass land in some detail, and advocates the reduction of this type of pasture and the devotion of a much larger area to alternate husbandry in which he considers our most valuable fodder grasses can be employed to best advantage. He also urges the desirability of raising in this country pure stocks of native British grasses, and refers to the work in this direction already carried out at the Plant Breeding Institute at Cam-

bridge. Hitherto the great bulk of the grass seeds used in this country has been produced abroad, and it is regarded as open to doubt whether such seed is as satisfactory as material raised at home. An appendix comprises a list of rare or introduced foreign grasses not described in the body of the work, and a useful bibliography. The index includes a list of synonyms and a glossary.

La Sériciculture en Pays Tropical. Etude pratique d'acclimatation du ver à soie du mûrier et du mûrier à Madagascar. By A. Fauchère, Inspecteur d'Agriculture, adjoint au chef de la Mission permanente d'Agriculture Coloniale. Pp. 119, Roy. 8vo. (Paris: Augustin Challamel, 1917.)

The production of silk has long been carried on by the natives in the central region of Madagascar, the whole of the crop being utilised locally. Formerly the industry depended for its raw material on the wild silkworm, the "landibe" (*Borocera madagascariensis*), which lives abundantly in the "tapia" (Chrisopia) and "afiafy" (Rhizophora) forests that exist in various parts of the island. Of late years, however, the greater part of the silk has been derived from the mulberry silkworm, and it is estimated that in 1914 the production of such cocoons in the Province of Antananarivo amounted to about 100 tons. This result is not regarded as commensurate with the efforts which have been made by the Administration to develop silk culture in the centre of the island. The slowness of the development is doubtless due to the difficulty of producing an abundance of mulberry leaves in this region as food for the silkworms. The land in central Madagascar consists of bare hills, which do not lend themselves to any profitable cultivation, and the lower levels, which are marshy, are partly used by the natives for rice growing. It has been found that the latter areas would be quite suitable for mulberry trees if they were thoroughly drained, and it is considered that if this were done, silk rearing would undergo rapid expansion.

In the book under consideration, the author gives a full account of the mulberry tree and its cultivation, the rearing of silkworms, the treatment of their diseases, and the production of seed, the special needs of Madagascar being borne in mind throughout. The silk cocoons produced in the centre of Madagascar resemble those of the Cevennes and are of very promising quality. Emphasis is laid on the importance of increasing the production and creating a large export trade for the benefit both of

the natives of Madagascar and the silk spinners of France.

The book is carefully written, contains a number of useful illustrations, and will be of service not only to silk rearers in Madagascar, but also to those in other countries and particularly in tropical areas.

A Laboratory Manual in Farm Machinery. By Frederick A. Wirt, B.S.C.E. Pp. xxii + 163, Demy 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1917.) Price 6*s*. net, post free, United Kingdom and abroad 6*s*. 5*d*.

This manual belongs to the Wiley agricultural engineering series of handbooks, and is intended for use in agricultural colleges in the United States. It is divided into three parts, viz.: (1) Farm Field Machinery, (2) Power Farming Machinery, and (3) Farm Mechanics. The first two parts consist of questions and exercises relating to the two classes of machinery dealt with, and these are designed "to lead the students to draw their own conclusions as to which machines are best adapted to the various agricultural conditions." The third part contains information regarding ropes and belts, knots and splices, and the operations of barbitting, soldering and pipe-cutting, with exercises and questions. Appended is a bibliography relating to the machinery and operations on which the questions and exercises on the manual are based.

In view of the importance of machinery in modern agricultural operations, it is essential that a detailed knowledge of this subject should be acquired by the student, and to this end this manual should prove of considerable assistance.

Refractory Materials: their Manufacture and Uses. By Alfred B. Searle. Pp. xii + 444, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1917.) Price 15*s*. net; post free, United Kingdom 15*s*. 6*d*., abroad 15*s*. 10*d*.

This book will be welcomed by British readers, dealing as it does in a comprehensive way with refractory materials, the importance of which has perhaps only been fully realised in British manufacturing industries since the outbreak of the war. At present it is a mere platitude to state that lack of research, combined with indifference as to the source of supply of refractory products has led to a serious neglect of British raw materials among manufacturers.

It was known before the war that the British Isles were well provided with refractory sands and clays of good

quality and that the success of German manufacturers was due not so much to the superiority of their resources in raw materials as to their research methods and technical equipment which enabled them to make more effective use of these materials.

This book deals at considerable length with the nature and sources of the raw materials required for the manufacture of refractory products. The various materials and processes involved in the manufacture of different kinds of refractory bricks are elaborately described. Chapters are devoted to saggars, muffles, crucibles and scorifiers, glass pots, retorts, refractory porcelain, refractory mortars and cements, and an account given in each case of their uses, manufacture and properties. The closing chapter deals with the selection and application of refractory materials; and specifications for various refractory materials are enumerated in an appendix.

Mr. Searle's book will doubtless do much to stimulate an interest in this important subject and direct the attention of British manufacturers to stores of raw material that have been hitherto neglected.

VOL. XV, 1917

INDEX

Botanical names and titles of books reviewed are printed in italics

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